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Inventory of Combustion-Related Emissions from Stationary Sources (First Update)

Aerospace Corp, El Segundo, Calif

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, N C

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16. ABSTRACT

The report describes the first 2 years of a study covering the combustion-related emissions phase of a 3-year program entitled, 'Analysis of NOx Control in Stationary Sources.' The study is aimed at assisting in the establishment of priorities for detailed studies of techniques for the control of combustion-related emissions from stationary sources. The inventory includes emissions of oxides of nitrogen, hydrocarbons, carbon monoxide, and particulate matter, not only from stationary sources primarily involving combustion, but also from other stationary sources where combustion plays a secondary role. During the first year of the study, emissions were established for 1975 and 1980 from boilers, internal combustion engines, chemical manufacturing, and petroleum refining. During the second year, emissions were established for 1976 and 1981 for primary metals and hydrocarbon evaporation, as well as for the four industries studied the first year. The third year will cover mineral products, secondary metals, and wood products. The report identifies approximately 68% of particulate matter and between 93% and 97% of NOx, hydrocarbon, and carbon monoxide emissions from stationary sources.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution, Combustion, Exhaust Gases	Air Pollution Control	13B, 21B
Nitrogen Oxides, Hydrocarbons	Stationary Sources	07B, 07C
Evaporation, Carbon Monoxide, Dust	Emissions Inventory	07D, , 11G
Boilers, Internal Combustion Engines	Primary Metals	13A, 21G
Chemical Industry, Petroleum Refining	Hydrocarbon Evaporation	07A, 13H
Coal, Fuel Oil, Natural Gas	Evaporative Emissions	21D

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EPA-600/2-77-066a
March 1977

INVENTORY OF COMBUSTION-RELATED EMISSIONS FROM STATIONARY SOURCES

(FIRST UPDATE)

by

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ABSTRACT

This report describes the first and second years of a study performed by The Aerospace Corporation to satisfy the Emissions Inventory phase of a federal grant entitled "Analysis of NO_x Control in Stationary Sources." The grant defines a three-year program covering the period 15 July 1974 to 14 July 1977. The purpose of this phase of the program is to assist the Environmental Protection Agency in establishing priorities for detailed studies of techniques for the control of combustion-related stationary source atmospheric emissions of (1) oxides of nitrogen, (2) unburned hydrocarbons, (3) carbon monoxide, and (4) particulate matter. The emissions inventoried are to be not only from recognized major stationary combustion sources but also from other stationary source categories in which combustion plays a secondary role. During the first year of this study, emissions were established for 1975 and projected to 1980 from boilers, internal combustion engines, chemical manufacturing, and petroleum refining. In the second year, emissions data for 1976 and 1981 were obtained for point-source evaporation and primary metals industries, and the first year's inventory was expanded to include 1976 and 1981. The third year of the study will cover mineral products, secondary metals, and wood products. This (second year) report identifies approximately 68 percent of all particulate emissions and from 93 to 97 percent of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen for stationary point sources.

This report is submitted by The Aerospace Corporation under sponsorship of the Environmental Protection Agency in partial fulfillment of Grant Number R803283. The remainder of the grant involves an analysis of oxides of nitrogen. The first-year results of the emissions inventory study have been reported by Aerospace in Inventory of Combustion-Related Emissions from Stationary Sources, EPA-600/7-76-012, dated September 1976.

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SECTION I

EXECUTIVE SUMMARY

1.1 INTRODUCTION

1.1.1 Background

A cost-effective approach to nationwide reduction of air pollution requires an accurate assessment of the air pollutants being discharged into the atmosphere by combustion-related processes and other related activities. Since there is a long lead time between the recognition of a large source of air pollution and the implementation of control methods, it is further required that the magnitude of these emissions be estimated for an appropriate time in the future.

Studies of specific industries have been and are being conducted. Because the sources of air pollution are numerous and geographically scattered, few studies have involved the gathering of significant samples of measured emission data. Most tend to review, analyze, summarize, and project the same data.

The National Emissions Data System (NEDS) of the U.S. Environmental Protection Agency (EPA) has generated a large volume of detailed, measured emission data, covering a wide range of industries. Most of these data were gathered in the 1970 through 1972 time period. Efforts to update the data base are continuing. However, as of 1975, the NEDS data were incomplete, contained some errors, and represented data from an average time period of about 1971. The NEDS contains no means for projecting the data beyond the acquisition period. Despite these drawbacks, the NEDS has the largest, most comprehensive, and detailed sample of original emission data available.

The other studies containing original data surveys serve as a check on the completeness of the NEDS data and provide the rationale for projection of the data into the future.

1.1.2 Scope

The purpose of this study, which is part of a three-year program, is to assist the EPA in establishing priorities for combustion-related detailed air pollution control studies. The atmospheric pollutants of interest are oxides of nitrogen (NO_x) unburned hydrocarbons (HC), particulate matter (PART), and carbon monoxide (CO). The study utilizes the NEDS original emission data base, as well as original data obtained from individual studies, to generate a detailed inventory of emissions, with projections to the early 1980s.

The nationwide emissions inventory compiled by this study is limited to atmospheric point source emissions. Point sources are defined as stationary sources contributing more than 100 tons per year of pollutant. Area sources, i.e., stationary sources of pollution exclusive of point sources, are considered only in cases where a point source is likely to develop.

The industries from which the emissions of interest emanate are referred to as process or source categories and are classified under the NEDS Source Classification Code (SCC). A detailed breakdown of these source categories is further defined by the Modified SCC (MSCC) developed by The Aerospace Corporation for this study. The emissions inventoried during the first year of the study, reported here, are from the following major source categories: external combustion in boilers, internal combustion, chemical manufacturing, and petroleum refineries. Evaporation and primary metals emissions were studied in the second year of the program; emissions from mineral product, secondary metal, and wood product industries will be investigated in the third year.

Uncertainty values are given for the current emission estimates and for emission projections to the early 1980s. The variables determining these values are process usage rates, emission factors, control applications, and time derivatives or trends. Statistical engineering estimates, current and potential legislative controls, and several independent sources of data were considered in calculating the uncertainty of each of the emissions inventoried.

1.1.3 Objectives

The objectives of this study are as follows:

a. Establish current and future five-year estimates of significant nationwide atmospheric stationary point source emissions of particulates, NO_x, HC, and CO, particularly from industries involving combustion.

b. Determine the uncertainty of current and future emission rates.

1.1.4 Approach

The objectives of the study were accomplished by the performance of the following tasks:

a. Establish a list of processes which yield a significant quantity of atmospheric emissions. The selection of processes and subprocesses is described in Sections 1.4.1 and 1.4.2.

b. Determine a data base (starting point) and slopes for time-dependent variables from which current and future emissions can be calculated. Accomplishment of this task for each process is described in Sections II through VII.

c. Establish and code equations, for computer usage, which allow emissions and their uncertainties to be estimated for the year of interest. Section 1.5 describes these equations.

d. Calculate and publish emissions for the current year and the fifth year hence. The detailed results of these calculations are listed for each process in Sections II through VII. The summarized results are published in Section 1.3.

1.1.5 Organization of Report

The Executive Summary section presents (1) an overview of the study and a concise review of the significant results; (2) an inventory summary of the 1975, 1976, 1980, and 1981 emissions, charge rates, and uncertainties for the broadest categories of the process studies; and (3) a description of the data acquisition techniques and the methods used to perform the computational analyses. Each of the major processes studied in the emissions inventory is presented separately in Sections II through VII. For the convenience of selective users, these sections are independently oriented.

The overall study is a three-year effort scheduled to continue to July 1977. Each year, a selected industry, process, or group of sources is studied. Also, during the third year, the inventory of the previous two years will be updated. The basic report will be revised annually during the course of the study, with subsequent inventories and updates of previous inventories incorporated.

Metric equivalents for English units used in this report are listed in the conversion table in Appendix A. A glossary of terms is provided in Appendix B.

1.2 STUDY SUMMARY

A summary of the stationary point source emissions inventory conducted in the first and second years of this program is given in Table 1-1 for 1975 and 1980 and in Table 1-2 for 1976 and 1981, respectively; a summary of all stationary source emissions is shown in Figures 1-1 and 1-2. The general trend of reduced emissions--or, at worst, small increases--over the next five years is attributed to increased compliance with new standards during this period even though industrial production is expected to increase appreciably. The most noteworthy emission rate determined is the 1975 CO value from petroleum refineries, which is 17-million tons per year. This number is approximately four times that reported in any of the recent NEDS nationwide emission summary reports. The difference is attributed partially to the emission factors used in computing emissions from fluid catalytic cracking processes, but the exact cause for the difference is unresolved at this writing.

As shown in Table 1-3, which identifies the contribution of the inventoried emissions to the total point source emissions, approximately 95 percent of the NO_x and 28 to 33 percent of the HC, CO, and PART are

Table 1-1. 1975 AND 1980 STATIONARY SOURCE EMISSIONS

Source Category	Emissions, million tons/yr[c]			
	NO_x	HC	CO	PART
Steam Boilers:[a]				
1975	7.59	0.15	0.37	5.58
1980	6.22	0.19	0.44	5.68
Internal Combustion Engines:[a]				
1975	0.60	0.35	Neg	Neg
1980	0.57	0.42	Neg	Neg
Chemical Manufacturing:[a]				
1975	Neg	1.08	2.63	Neg
1980	Neg	1.13	2.76	Neg
Petroleum Refineries:[a]				
1975	0.56	0.41	17.04	0.30
1980	0.38	0.45	11.61	0.24
Internal Combustion Engines:[b]				
1980	2.96	0.99	13.57	Neg

[a] Point source: more than 100 tons per year of pollutant.

[b] Area source: all stationary sources exclusive of point sources.

[c] Neg is defined as less than 1% of the NEDS 1975 stationary source emissions.

Table 1-2. 1976 AND 1981 STATIONARY SOURCE EMISSIONS

Source Category	Emissions, million tons/yr[a]			
	NO_x	HC	CO	PART
Steam Boilers				
1976	7.37	0.16	0.39	5.65
1981	5.88	0.20	0.46	5.62
Internal Combustion Engines				
1976	0.60	0.36	Neg	Neg
1981	0.56	0.43	Neg	Neg
Chemical Manufacturing				
1976	Neg	1.09	2.65	Neg
1981	Neg	1.14	2.79	Neg
Petroleum Refineries				
1976	0.52	0.42	16.09	0.29
1981	0.35	0.46	10.32	0.22
Primary Metals				
1976	0.01	0.20	11.35	1.55
1981	0.01	0.20	6.66	0.71
Evaporation Point Source				
1976	Neg	4.24	Neg	Neg
1981	Neg	2.43	Neg	Neg
Area Source[b]				
1976	Neg	0.63	Neg	Neg
1981	Neg	0.14	Neg	Neg

[a] "Neg" is defined as less than 1% of the 1975 NEDS value for that emission.

[b] Retail service stations.

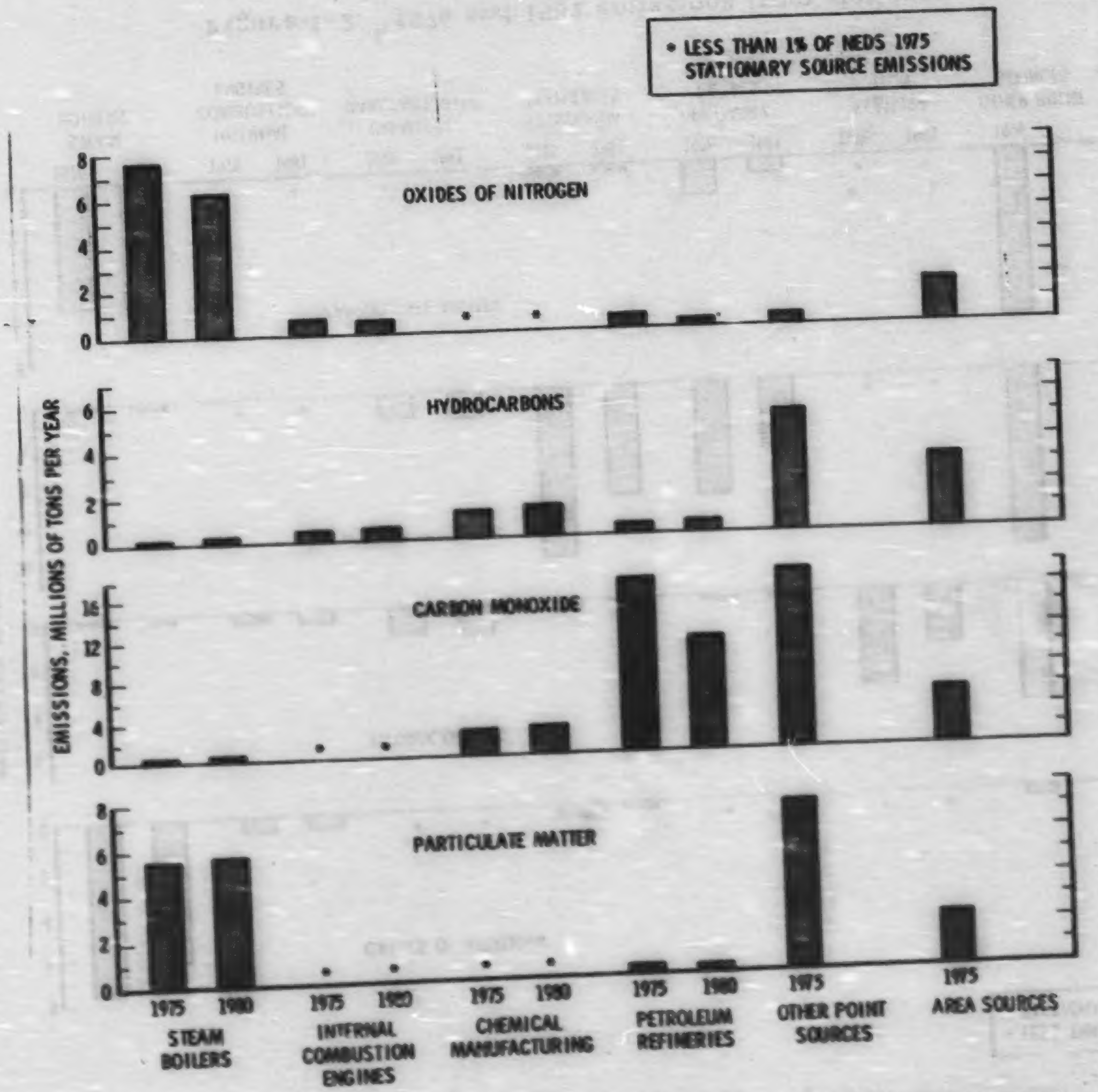

Figure 1-1. 1975 and 1980 emissions from stationary sources

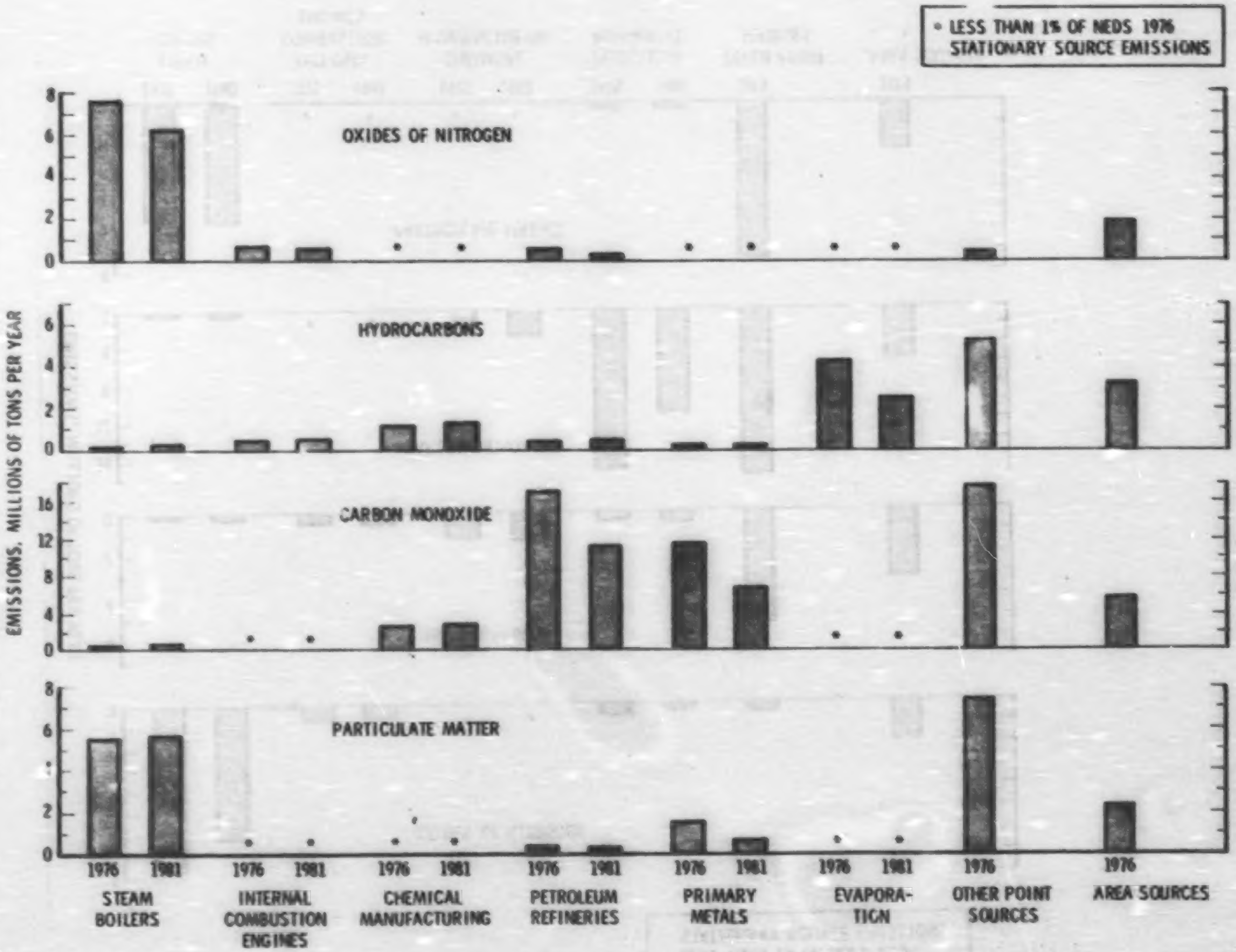

Figure 1-2. 1976 and 1981 emissions from stationary sources

accounted for in the initial inventory. When the second year inventory is included, 93 to 97 percent of the NO_x, HC, and CO emissions are accounted for and 68 percent of the PART (Table 1-4). Most of the remainder will be inventoried during the third year of this program, which will be concerned with mineral product, secondary metal, and wood product emissions.

The uncertainties of the 1975 and 1980 point source emissions were computed and are presented in Table 1-5. Table 1-6 shows similar data for 1976 and 1981. As shown, significant uncertainties in emission rate predictions exist for CO from petroleum refineries. Expressed as a percentage of the nominal value of the predicted emissions, the uncertainty of 1975 CO emissions from refineries is approximately 35 percent. This large uncertainty is due to the lack of substantiated emission factor data for fluid catalytic cracking facilities. Refinements in data are expected to significantly reduce this uncertainty in the updates planned for the third year of the study.

Significant quantities of NO_x, HC, and CO emissions are predicted for stationary area source internal combustion (IC) engines which far exceed the emissions attributed to present point source IC engines. The difference in emissions is attributed to IC engines whose usage, emission factor, or size is too small to qualify them as point source emitters and consequently are classified as area source emitters. The four highest polluting IC engines contributing to area source emissions were studied because many are in a standby installation and, with a modest increase in usage, could become point sources of significant quantities of emissions. These four offenders are (1) distillates, (2) crude-oil-fueled turbines, (3) diesel engines, and (4) gasoline-fueled reciprocating engines. A detailed description of these area source emissions is presented in Section 3.4. The gasoline engine contributes the largest amount of NO_x, HC, and CO, particularly CO whose rate of 13 million tons per year is two orders of magnitude greater than that of any other area source emission from IC engines. Since the primary objective was to establish an inventory of point source emissions, area source emissions are not included in the basic inventory as summarized in Section 1.3

Table 1-3. 1975 DISTRIBUTION OF POINT SOURCE EMISSIONS

Source Category	Percent of Total Point Source Emissions[a]			
	NO_x	HC	CO	PART
Steam Boilers	81	2	1	41
Internal Combustion Engines	6	5	Neg	Neg
Chemical Manufacturing	2	15	7	2
Petroleum Refineries	6	6	45	2
Total Initial Inventory	95	28	53	46
Other Point Sources	5	72	47	54
Total Point Sources	100	100	100	100

[a] Neg is less than 0.5%

Table 1-4. 1976 DISTRIBUTION OF POINT SOURCE EMISSIONS

Source Category	Percent of Total Point Source Emissions[a]			
	NO_x	HC	CO	PART
Steam Boilers	82	2	1	39
Internal Combustion Engines	7	5	Neg	Neg
Chemical Manufacturing	2	16	8	2
Petroleum Refineries	6	6	49	2
Primary Metals	Neg	3	35	25
Point Source Evaporation	Neg	61	Neg	Neg
Total Emissions Inventoried During First and Second Year of Study	97	93	93	68
Other Point Source Emissions[b]	3	7	7	32
Total Point Source Emissions	100	100	100	100

[a] "Neg" is defined as less than 0.5%.

[b] Based on data listed in the NEDS summary report, dated January 1, 1976.

Table 1-5. 1975 AND 1980 UNCERTAINTIES IN POINT SOURCE EMISSION RATES

Source Category	Emissions, million tons/yr[a]			
	NO_x	HC	CO	PART
Steam Boilers				
1975	+0.42 -0.42	+0.10 -0.02	+0.08 -0.05	+0.47 -0.47
1980	+0.85 -0.81	+0.12 -0.03	+0.10 -0.07	+0.87 -0.87
Internal Combustion Engines				
1975	+0.39 -0.14	+0.18 -0.08	Neg	Neg
1980	+0.42 -0.18	+0.26 -0.11	Neg	Neg
Chemical Manufacturing				
1975	Neg	+0.10 -0.10	+0.37 -0.37	Neg
1980	Neg	+0.11 -0.11	+0.43 -0.43	Neg
Petroleum Refineries				
1975	+0.03 -0.03	+0.04 -0.04	+5.89 -5.89	+0.01 -0.01
1980	+0.03 -0.03	+0.05 -0.05	+6.72 -6.72	+0.02 -0.02

[a] Neg corresponds to the nominal emission equaling less than 1% of total stationary source emissions.

Table 1-6. UNCERTAINTIES IN 1976 AND 1981 POINT SOURCE EMISSIONS

Source Category	Emission Uncertainty, million tons/yr[a]			
	NO_x	HC	CO	PART
Steam Boilers				
1976	+0.50 -0.50	+0.10 -0.02	+0.08 -0.06	+0.53 -0.53
1981	+0.95 -0.90	+0.13 -0.03	+0.11 -0.07	+0.97 -0.97
Internal Combustion Engines				
1976	+0.40 -0.14	+0.19 -0.06	Neg Neg	Neg Neg
1981	+0.43 -0.18	+0.28 -0.13	Neg Neg	Neg Neg
Chemical Manufacturing				
1976	Neg Neg	+0.10 -0.10	+0.37 -0.37	Neg Neg
1981	Neg Neg	+0.12 -0.12	+0.46 -0.45	Neg Neg
Petroleum Refineries				
1976	+0.03 -0.03	+0.04 -0.04	+6.05 -6.05	+0.01 -0.01
1981	+0.03 -0.03	+0.05 -0.05	+6.88 -6.88	+0.02 -0.02
Primary Metals				
1976	+0.00 -0.01	+0.02 -0.05	+1.29 -1.29	+0.40 -0.29
1981	+0.00 -0.01	+0.04 -0.12	+3.65 -2.58	+0.15 -0.12
Evaporation				
1976	Neg Neg	+0.46 -0.45	Neg Neg	Neg Neg
1981	Neg Neg	+0.58 -0.46	Neg Neg	Neg Neg

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[a] "Neg" is defined as the nominal emission equaling less than 1% of total stationary sources.

The HC emissions lost to the atmosphere by evaporation were estimated to be 4.25-million tons in 1976 and are expected to be reduced to 2.5-million tons in 1981. The projected reduction is primarily due to improved storage facilities for petroleum products.

1.3 INVENTORY SUMMARY

The categories studied are classified and summarized under the processes contributing the stationary source emissions of interest. In Table 1-7, the major process categories investigated are listed and defined according to the NEDS Modified Source Classification Code (MSCC) and charge rate unit. The 1975 and 1980 emissions are summarized by major process category in Tables 1-8-a and 1-9-a, respectively. The respective uncertainties for these emissions are given in Tables 1-8-b and 1-9-b. Similar data are presented for 1976 and 1981 in Tables 1-10 and 1-11, respectively.

In these tables, three levels of summarization are defined by the NEDS nine-digit MSCC number. The first, most general, summary level is indicated by the first digit of the MSCC. The emissions listed in the first-level summary categories are the sum of those in the second-level summary, and those in the second level are the sum of those in the third level. Second-level categories are indicated by the second and third digits in the MSCC, and the third-level summary categories by the numbers in the fourth, fifth, and sixth digits.

No charge rates are listed for the first level and only a few for the second-level summary categories because these categories represent different types of processes with different units of measure. For example, the second-level summary category 101000000 represents all external combustion for boilers used in electric generation including those burning coal in tons per year, oil in thousands of gallons per year, and natural gas in millions of cubic feet per year. In some cases, third-level summaries involve a single process type with the same unit, e.g., 101002000, bituminous coal in tons per year. In such cases, the appropriate MSCC unit of measure is shown in Table 1-7, and a charge rate for this unit is listed in Tables 1-8 through 1-11.

The major source categories summarized here are further classified and detailed in Sections II through VII.

(Continued on page 1-83)

Table 1-7. DEFINITION OF SUMMARY CATEGORIES

MSCC	Source Category	Charge Rate Unit[a]
100000000	**External Combustion (Boiler)**	
101000000	**Electric Generation**	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
102000000	**Industrial**	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr
200000000	**Internal Combustion**	
201000000	**Electric Generation**	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.
202000000	**Industrial IC Engines**	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[b]	Million cu ft/yr
300000000	**Industrial Processes**	
301000000	**Chemical Manufacturing**	
301002000	Ammonia production with methanator	Tons/yr

Table 1-7. DEFINITION OF SUMMARY CATEGORIES (Continued)

MSCC	Source Category	Charge Rate Unit[a]
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr
303000000	Primary Metals	N. A.
303001000	Aluminum reduction	Aluminum, tons/yr
303002000	Aluminum ore calcined	Tons/yr
303003000	Coke metallurgical	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303005000	Copper smelters	N. A.
303006000	Ferroalloy production (open furnace)	Tons/yr
303007000	Ferroalloy production (closed furnace)	
303008000	Iron production	N. A.
303009000	Steel production	Tons/yr
303010000	Lead smelters	N. A.
303011000	Molybdenum	N. A.
303012000	Titanium	N. A.
303030000	Zinc smelting	Tons/yr
303999000	Miscellaneous metallurgical processes	Tons/yr
306000000	Petroleum Industry	
306001000	Process heater	N. A.
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	Capacity, 1000 bbl/yr
306012000	Fluid coking	Feed, 1000 bbl/yr

Table 1-7. DEFINITION OF SUMMARY CATEGORIES (Continued)

MSCC	Source Category	Charge Rate Unit[a]
400000000	Point Source Evaporation	N. A.
401000000	Cleaning Solvents	N. A.
401001000	Dry cleaning	Clothes, tons/yr
401002000	Degreasing	Solvent, tons/yr
401999000	Miscellaneous solvent use	Solvent, tons/yr
402000000	Surface Coating	Coating, tons/yr
402001000	Paint	Coating, tons/yr
402002000	Paper coatings	Coating, tons/yr
402003000	Varnish and shellac	Coating, tons/yr
402004000	Lacquer	Coating, tons/yr
402005000	Enamel	Coating, tons/yr
402006000	Primer	Coating, tons/yr
402007000	Fabric coatings	Coating, tons/yr
402008000	Oven coatings	Coating, tons/yr
402999000	Miscellaneous coatings	Coating, tons/yr
403000000	Petroleum Storage	N. A.
403001000	Fixed roof	N. A.
403002000	Floating roof	N. A.
403003000	Variable vapor space	1000 gal/yr
403999000	Miscellaneous storage	1000 gal/yr
406000000	Petroleum Marketing and Transportation	1000 gal/yr
406001000	Rail and truck transportation	1000 gal/yr
406002000	Marine vessel transportation	1000 gal/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

[b] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-8-a. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES

```
                              EXTERNAL COMBUSTION, BOILER CATEGORY              PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975      RUN DATE= MAR 22,1977
 MODIFIED         TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX           HC            CO           PART

100000000                          7.591         .147          .371         5.579

101000000                          6.237         .090          .252         4.301

101002000       389250000.         4.397         .070          .199         4.205
101004000        18210000.          .667         .018          .027          .073
101005000               0.         0.000        0.000         0.000         0.000
101006000         2993400.          .673         .001          .025          .022
101007000           90390.          .000     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

102000000                          1.354         .057          .119         1.279

102002000        57234000.          .592         .023          .051         1.055
102004000        12100000.          .290         .018          .024          .139
102005000         7060000.          .169         .011          .014          .053
102006000         3520000.          .303         .005          .030          .032
102007000         1749300.          .000     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-8-a. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES (Continued)

```
                         INTERNAL COMBUSTION ENGINES                           PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975        RUN DATE= MAR 22,1977
 MODIFIED          TACRP          EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)      NOX          HC          CO          PART
200000000                      .604         .348        .067         .017
201000000                      .244         .086        .016         .011
201001000        1088100.      .120         .002        .010         .008
201002000         338860.      .096         .001        .000         .000
201003000          75159.      .011         .001        .005         .002
201999000                      .017         .083        .002         .001
```

MSCC	Source Category	Charge Rate Unit
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.[a]

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[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

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Table 1-8-a. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES (Continued)

```
                               INTERNAL COMBUSTION ENGINES                     PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975      RUN DAT'= MAR 22,1977
 MODIFIED        IACRP             EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)         NOX            HC            CO            PART
                                  .360          .261          .051           .006
202000000

202001000         65953.          .004          .000          .002           .001
202002000        973960.          .348          .089          .044           .004
202003000          3470.          .000          .000          .003           .000
202004000         26201.          .005          .000          .002           .000
202999000         23828.          .003          .172          .001           .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-8-a. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES (Continued)

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                        INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING                 PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975     RUN DATE= MAR 22,1977
                                     EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED        TACRP                                  HC          CO            PART
  SCC        (SCC UNITS)          NOX
                                                      1.080       2.625        NEGLIGIBLE
301000000                     NEGLIGIBLE

301002000         6106000.    NEGLIGIBLE               .209        .003        NEGLIGIBLE
301003000         2443000.    NEGLIGIBLE               .031        .046        NEGLIGIBLE
301005000         6054400.    NEGLIGIBLE               .322       2.241        NEGLIGIBLE
301999000       151180000.    NEGLIGIBLE               .518        .336        NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-8-a. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES (Continued)

PAGE 1

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE- MAR 22,1977

		EMISSIONS (MILLIONS OF TONS / YEAR)			
MODIFIED SCC	TACRP (SCC UNITS)	NOX	HC	CO	PART
306000000		.557	.407	17.044	.302
306001000	1500000.	.507	.045	.034	.095
306002000	108500.	.050	.170	16.800	.180
306003000	26250000.	NEGLIGIBLE	.005	.210	NEGLIGIBLE
306008000	110000.	NEGLIGIBLE	.187	NEGLIGIBLE	NEGLIGIBLE
306012000		NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.027

MSCC	Source Category	Charge Rate Unit
306000000	Petroleum Industry	N.A.[a]
306001000	Process heater	1000 bbl/yr
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl capacity/yr
306008000	Miscellaneous leakage	
306012000	Fluid coking	1000 bbl feed/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-8-b. SUMMARY of 1975 EMISSIONS AND CHARGE RATES UNCERTAINTY

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                  EXTERNAL COMBUSTION, BOILER CATEGORY                      PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975        RUN DATE= MAR 22,1977
 MODIFIED           TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX          HC            CO           PART
100000000                          + .417      + .099       + .077       + .471
                                   - .418      - .020       - .052       - .471

101000000                          + .386      + .097       + .071       + .431
                                   - .386      - .015       - .048       - .431

101002000   +   11708000.          + .348      + .097       + .069       + .431
            -   11708000.          - .348      - .014       - .046       - .431
101004000   +    2111300.          + .094      + .008       + .012       + .008
            -    2111300.          - .094      - .006       - .008       - .008
101005000   +          0.          + 0.000     + 0.000      + 0.000      + 0.000
            -          0.          - 0.000     - 0.000      - 0.000      - 0.000
101006000   +     590090.          + .139      + .001       + .012       + .004
            -     590090.          - .139      - .001       - .009       - .004
101007000   +      15220.          + .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
            -      15220.          - .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr

Table 1-8-b. SUMMARY OF 1975 EMISSIONS AND CHARGE RA.ES UNCERTAINTY (Continued)

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                                      EXTERNAL COMBUSTION, BOILER CATEGORY                        PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975                              RUN DATE= MAR 22,1977
                                                 EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED        TACRP                    NOX             HC                  CO                  PART
  SCC        (SCC UNITS)

102000000                             + .158          + .016              + .030              + .190
                                      - .160          - .013              - .022              - .190

102002000   +     6431600.            + .075          + .010              + .020              + .190
            -     6431600.            - .075          - .010              - .014              - .190
102004000   +     1140100.            + .093          + .010              + .012              + .013
            -     1140100.            - .093          - .007              - .009              - .013
102005000   +      838110.            + .060          + .006              + .008              + .006
            -      838110.            - .060          - .004              - .006              - .006
102006000   +      902520.            + .084          + .003              + .017              + .008
            -      902520.            - .089          - .002              - .012              - .008
102007000   +      142990.            + .000          NEGLIGIBLE          NEGLIGIBLE          NEGLIGIBLE
            -      142990.            - .000          NEGLIGIBLE          NEGLIGIBLE          NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-8-b. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                                 INTERNAL COMBUSTION ENGINES                              PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975                    RUN DATE= MAR 22,1977
 MODIFIED          TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)            NOX              HC               CO              PART

200000000                            + .393           + .178           + .038           + .025
                                     - .137           - .047           - .013           - .009

201000000                            + .376           + .013           + .029           + .024
                                     - .122           - .012           - .010           - .008

201001000     +      3320600.        + .369           + .005           + .029           + .024
              -      1088100.        - .120           - .002           - .010           - .008
201002000     +       417670.        + .072           + .002           + .003           + .001
              -       110200.        - .022           - .001           - .000           - .000
201003000     +        14799.        + .003           + .000           + .002           + .001
              -        14799.        - .002           - .000           - .001           - .001
201999000                            + .003           + .012           + .000           + .001
                                     - .003           - .012           - .000           - .001
```

MSCC	Source Category	Charge Rate Unit
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.[a]

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-8-b. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                       INTERNAL COMBUSTION ENGINES                                   PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975               RUN DATE= MAR 22,1977
                                              EMISSIONS (MILLIONS OF TONS    YEAR)
MODIFIED        TACRP                   NOX              HC               CO            PART
  SCC       (SCC UNITS)
                                   + .112           + .177           + .024          + .005
202000000                          - .061           - .045           - .008          - .004

202001000   +     22224.           + .001           + .000           + .001          + .000
            -     22224.           - .001           - .000           - .001          - .000
202002000   +    616740.           + .111           + .030           + .024          + .005
            -    174900.           - .061           - .016           - .008          - .004
202003000   +      1172.           + .000           + .000           + .002          + .000
            -      1172.           - .000           - .000           - .001          - .000
202004000   +     26055.           + .005           + .000           + .002          + .000
            -     26055.           - .005           - .000           - .002          - .000
202999000   +      5925.           + .001           + .175           + .000          + .000
            -      5925.           - .001           - .043           - .000          - .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-8-b. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                    INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING              PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975        RUN DATE= MAR 22,1977
 MODIFIED         TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX              HC              CO              PART
301000000                        NEGLIGIBLE     +  .101      +  .365      NEGLIGIBLE
                                 NEGLIGIBLE     -  .101      -  .365      NEGLIGIBLE

301002000   +      229110.       NEGLIGIBLE     +  .020      +  .001      NEGLIGIBLE
            -      229110.       NEGLIGIBLE     -  .020      -  .001      NEGLIGIBLE
301003000   +       54487.       NEGLIGIBLE     +  .004      +  .031      NEGLIGIBLE
            -       54487.       NEGLIGIBLE     -  .004      -  .031      NEGLIGIBLE
301005000   +      226540.       NEGLIGIBLE     +  .072      +  .340      NEGLIGIBLE
            -      226540.       NEGLIGIBLE     -  .072      -  .340      NEGLIGIBLE
301999000   +    17464000.       NEGLIGIBLE     +  .065      +  .129      NEGLIGIBLE
            -    17464000.       NEGLIGIBLE     -  .065      -  .129      NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-8-b. SUMMARY OF 1975 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                                                                        PAGE  1
                  INDUSTRIAL PROCESS, PETROLEUM PRODUCTS
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE, MAR 22,1977
                                   EMISSIONS (MILLIONS OF TON  / YEAR)
MODIFIED          TACRP
  SCC          (SCC UNITS)       NOX           HC            CO           PART

306000000                      + .026        + .035        + 5.890       + .011
                               - .026        - .035        - 5.890       - .011

306001000                      + .025        + .006        + .005        + .003
                               - .025        - .006        - .005        - .003
306002000     +      30000.    + .003        + .009        + 5.890       + .010
              -      30000.    - .003        - .009        - 5.890       - .010
306003000     +       2169.    NEGLIGIBLE    + .000        + .011        NEGLIGIBLE
              -       2169.    NEGLIGIBLE    - .000        - .011        NEGLIGIBLE
306008000     +     234790.    NEGLIGIBLE    + .034        NEGLIGIBLE    NEGLIGIBLE
              -     234790.    NEGLIGIBLE    - .034        NEGLIGIBLE    NEGLIGIBLE
306012000     +       2199.    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    + .002
              -       2199.    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    - .002
```

MSCC	Source Category	Charge Rate Unit
306000000	Petroleum Industry	N.A.[a]
306001000	Process heater	1000 bbl/yr
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl capacity/yr
306008000	Miscellaneous leakage	1000 bbl feed/yr
306012000	Fluid coking	

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-9-a. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES

```
                             EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE   1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980         RUN DATE= MAR 22,1977
                                     EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP
   SCC         (SCC UNITS)      NOX          HC            CO           PART

100000000                      6.217        .187          .442          5.675

101000000                      5.057        .110          .292          4.123

101002000       459910000.     4.688        .083          .234          4.001
101004000        26860000.      .245        .027          .040           .107
101005000              0.      0.000       0.000         0.000          0.000
101006000         1986900.      .124        .001          .017           .015
101007000           90390.      .000     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

102000000                      1.160        .077          .151          1.552

102002000        93319000.      .793        .037          .082          1.287
102004000        15350000.      .138        .023          .031           .177
102005000         8960000.      .081        .013          .018           .067
102006000         2320000.      .147        .003          .020           .021
102007000         1749300.      .000     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-9-a. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES (Continued)

```
                                INTERNAL COMBUSTION ENGINES                                  PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980       RUN DATE= MAR 22,1977
MODIFIED        TACRP                   EMISSIONS (MILLIONS OF TO'S / YEAR)
  SCC        (SCC UNITS)         NOX           HC            CO           PART
200000000
                                 .568          .418          .066          .018
201000000
                                 .255          .104          .018          .013
201001000      1275600.          .141          .002          .011          .009
201002000       290630.          .083          .000          .000          .000
201003000        82909.          .012          .001          .005          .002
201999000                        .019          .100          .002          .002
```

MSCC	Source Category	Charge Rate Unit
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.[a]

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-9-a. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES (Continued)

```
                          INTERNAL COMBUSTION ENGINES                           PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980      RUN DATE= MAR 22,1977
 MODIFIED        TACRP           EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)       NOX          HC            CO              PART
 202000000                     .313         .314          .047            .005

 202001000         79753.      .005         .000          .002            .001
 202002000        824330.      .297         .076          .037            .004
 202003000          4627.      .001         .001          .004            .000
 202004000         35626.      .006         .000          .003            .000
 202999000         32923.      .005         .237          .001            .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-9-a. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES (Continued)

```
                   INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING               PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980     RUN DATE= MAR 22,1977
 MODIFIED        TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)         NOX             HC              CO            PART

301000000                      NEGLIGIBLE        1.126           2.761        NEGLIGIBLE

301002000        7083000.      NEGLIGIBLE         .243            .003        NEGLIGIBLE
301003000        2832500.      NEGLIGIBLE         .036            .094        NEGLIGIBLE
301005000        6217000.      NEGLIGIBLE         .328           2.369        NEGLIGIBLE
301999000      151180000.      NEGLIGIBLE         .518            .336        NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-9-a. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES (Continued)

```
                  INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980     RUN DATE= MAR 22,1977
MODIFIED      TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC      (SCC UNITS)      NOX          HC           CO           PART
306000000                   .382         .454        11.609         .239

306001000                   .326         .055          .038         .082
306002000    1690000.       .056         .180        11.441         .128
306003000      70000.    NEGLIGIBLE      .003          .130      NEGLIGIBLE
306008000   29850000.    NEGLIGIBLE      .215      NEGLIGIBLE    NEGLIGIBLE
306012000     120000.    NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE       .029
```

MSCC	Source Category	Charge Rate Unit
306000000	Petroleum Industry	
306001000	Process heater	N.A.[a]
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	1000 bbl capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES UNCERTAINTY

```
                      EXTERNAL COMBUSTION, BOILER CATEGORY                    PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980          RUN DATE= MAR 22,1977
 MODIFIED         TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)        NOX            HC            CO           PART
100000000                      + .853        + .121        + .099        + .867
                               - .808        - .028        - .067        - .866

101000000                      + .798        + .119        + .088        + .812
                               - .780        - .019        - .059        - .811

101002000     +  30577000.     + .771        + .118        + .084        + .812
              -  30577000.     - .771        - .017        - .057        - .810
101004000     +   4618700.     + .155        + .012        + .019        + .018
              -   4618700.     - .094        - .009        - .013        - .018
101005000     +         0.     + 0.000       + 0.000       + 0.000       + 0.000
              -         0.     - 0.000       - 0.000       - 0.000       - 0.000
101006000     +   2029500.     + .136        + .001        + .019        + .015
              -   1115800.     - .071        - .001        - .009        - .008
101007000     +     15220.     + .000        NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
              -     15220.     - .000        NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980          RUN DATE= MAR 22,1977
 MODIFIED         TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)         NOX            HC              CO             PART

102000000                        + .303         + .023          + .046         + .304
                                 - .210         - .020          - .031         - .304

102002000    +   12611000.       + .171         + .017          + .034         + .302
             -   12611000.       - .171         - .017          - .024         - .302
102004000    +    1686600.       + .148         + .013          + .016         + .019
             -    1686600.       - .060         - .009          - .011         - .019
102005000    +    2072900.       + .096         + .009          + .011         + .016
             -    2072900.       - .041         - .006          - .008         - .016
102006000    +    2648100.       + .177         + .004          + .025         + .024
             -    1530900.       - .097         - .002          - .013         - .014
102007000    +     142990.       + .000         NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
             -     142990.       - .000         NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RA..ES UNCERTAINTY (Continued)

```
                              INTERNAL COMBUSTION ENGINES                            PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980            RUN DAT = MAR 22,1977
 MODIFIED         TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX              HC               CO            PART
200000000                         + .418           + .261           + .040         + .026
                                  - .176           - .113           - .017         - .010

201000000                         + .394           + .027           + .031         + .026
                                  - .143           - .026           - .011         - .009

201001000   +    3472000.         + .387           + .005           + .030         + .025
            -    1275600.         - .141           - .002           - .011         - .009
201002000   +     419680.         + .074           + .002           + .003         + .001
            -     109070.         - .023           - .000           - .000         - .000
201003000   +      18635.         + .003           + .000           + .002         + .001
            -      18635.         - .003           - .000           - .001         - .001
201999000                         + .005           + .026           + .001         + .001
                                  - .005           - .026           - .001         - .001
```

MSCC	Source Category	Charge Rate Unit
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.[a]

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                                                                          PAGE  2
                        INTERNAL COMBUSTION ENGINES
                                                                 RUN DATE= MAR 22,1977
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980
                                     EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED          TACRP                                            
   SCC          (SCC UNITS)        NOX            HC              CO             PART
                                 + .139         + .260          + .026          + .005
202000000                        - .102         - .110          - .013          - .003

202001000     +      49437.      + .003         + .000          + .001          + .001
              -      49437.      - .003         - .000          - .001          - .001
202002000     +     662170.      + .139         + .037          + .026          + .005
              -     276270.      - .102         - .026          - .013          - .003
202003000     +       2311.      + .000         + .000          + .003          + .000
              -       2311.      - .000         - .000          - .002          - .000
202004000     +      26452.      + .005         + .000          + .002          + .000
              -      26452.      - .005         - .000          - .002          - .000
202999000     +      14845.      + .002         + .258          + .001          + .000
              -      14845.      - .002         - .107          - .001          - .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels [a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                     INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980          RUN DATE, MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED           TACRP                               HC                 CO
   SCC          (SCC UNITS)           NOX                                                   PART
                                  NEGLIGIBLE       +  .113           +  .432          NEGLIGIBLE
301000000                         NEGLIGIBLE       -  .113           -  .432          NEGLIGIBLE

301002000      +       288470.    NEGLIGIBLE       +  .032           +  .001          NEGLIGIBLE
               -       288470.    NEGLIGIBLE       -  .032           -  .001          NEGLIGIBLE
301003000      +        68686.    NEGLIGIBLE       +  .005           +  .036          NEGLIGIBLE
               -        68686.    NEGLIGIBLE       -  .005           -  .036          NEGLIGIBLE
301005000      +       237320.    NEGLIGIBLE       +  .087           +  .111          NEGLIGIBLE
               -       237320.    NEGLIGIBLE       -  .087           -  .111          NEGLIGIBLE
301999000      +     17464000.    NEGLIGIBLE       +  .065           +  .129          NEGLIGIBLE
               -     17464000.    NEGLIGIBLE       -  .065           -  .129          NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-9-b. SUMMARY OF 1980 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                 INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980          RUN DATE= MAR 22,1977
 MODIFIED         TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)        NOX          HC            CO            PART
306000000                     + .033       + .046        + 6.723        + .016
                              - .033       - .046        - 6.723        - .016

306001000                     + .032       + .008        + .008         + .006
                              - .032       - .007        - .008         - .006
306002000  +     168980.      + .006       + .020        + 6.723        + .014
           -     168980.      - .006       - .020        - 6.723        - .014
306003000  +      21002.      NEGLIGIBLE   + .001        + .040         NEGLIGIBLE
           -      21002.      NEGLIGIBLE   - .001        - .040         NEGLIGIBLE
306008000  +    1375200.      NEGLIGIBLE   + .041        NEGLIGIBLE     NEGLIGIBLE
           -    1375200.      NEGLIGIBLE   - .041        NEGLIGIBLE     NEGLIGIBLE
306012000  +      11998.      NEGLIGIBLE   NEGLIGIBLE    NEGLIGIBLE     + .004
           -      11998.      NEGLIGIBLE   NEGLIGIBLE    NEGLIGIBLE     - .004
```

MSCC	Source Category	Charge Rate Unit
306000000	Petroleum Industry	
306001000	Process heater	N.A.[a]
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	1000 bbl capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

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[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES

```
                                                                              PAGE  1
                         EXTERNAL COMBUSTION, BOILER CATEGORY
                                                         RUN DATE= MAR 22,1977
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976
                                   EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED        TACRP             NOX          HC           CO           PART
   SCC        (SCC UNITS)

100000000                          7.373        .155         .385         5.647

101000000                          6.030        .094         .260         4.286

101002000     403380000.           4.880        .073         .206         4.183
101004000      19940000.            .620        .020         .030          .080
101005000             0.           0.000       0.000        0.000         0.000
101006000       2792100.            .537        .001         .014          .021
101007000         90390.            .000     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE

102000000                          1.335        .061         .126         1.361

102002000      44451000.            .644        .020         .037         1.129
102004000      12750000.            .268        .019         .026          .147
102005000       7440000.            .154        .011         .012          .038
102006000       3280000.            .267        .005         .028          .030
102007000       1749300.            .000     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                                                                  PAGE  1
                       INTERNAL COMBUSTION ENGINES
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976    RUN DATE= MAR 22,1977
                                    EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED      IACRP
  SCC      (SCC UNITS)       NOX          HC           CO          PART

200000000                    .597         .362         .067         .017

201000000                    .246         .090         .016         .011

201001000     1125600.       .124         .002         .010         .008
201002000      324210.       .094         .001         .000         .000
201003000       76709.       .011         .001         .005         .002
201999000                    .017         .087         .002         .001
```

MSCC	Source Category	Charge Rate Unit[a]
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.[a]

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                              INTERNAL COMBUSTION ENGINES                                    PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976                   RUN DATE= MAR 22,1977
 MODIFIED        TACRP                         EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC       (SCC UNITS)          NOX                 HC                  CO                 PART
202000000
                                  .351               .272                .051                .005

202001000        68713.           .004               .000                .002                .001
202002000       944040.           .338               .086                .043                .004
202003000         3702.           .000               .000                .003                .000
202004000        28089.           .002               .000                .002                .000
202999000        25647.           .004               .185                .001                .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                                                                      PAGE  1
                  INDUSTRIAL PRECESS, CHEMICAL MANUFACTURING
     ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976     RUN DATE= MAR 22,1977
                                    EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED        TACRP           NOX            HC            CO          PART
   SCC       (SCC UNITS)
 301000000                    NEGLIGIBLE       1.089         2.652     NEGLIGIBLE
 301002000      6301400.      NEGLIGIBLE        .216          .003     NEGLIGIBLE
 301003000      2520900.      NEGLIGIBLE        .032          .048     NEGLIGIBLE
 301005000      6086900.      NEGLIGIBLE        .323         2.267     NEGLIGIBLE
 301999000    151180000.      NEGLIGIBLE        .518          .336     NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	Tons/yr.
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                         INDUSTRIAL PROCESS, PRIMARY METALS                        PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976    RUN DATE= MAR 22,1977
MODIFIED        TACRP          EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC        (SCC UNITS)      NOX          HC            CO             PART
303000000                     .013         .198         11.352          1.552

303001000     22082000.    NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE          .115
303002000      8964000.    NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE          .043
303003000    458400000.       .002         .184         .056             .088
303004000      1390000.    NEGLIGIBLE      .006         .001             .132
303005000                  NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE          .347
303006000      4333800.    NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE          .160
303007000      2480000.    NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE          .003
```

MSCC	Source Category	Charge Rate Unit[a]
303000000	Primary Metals	N. A.
303001000	Aluminum reduction	Aluminum, tons/yr
303002000	Aluminum ore calcined	Tons/yr
303003000	Coke metallurgical	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303005000	Copper smelters	N. A.
303006000	Ferroalloy production (open furnace)	Tons/yr
303007000	Ferroalloy production (closed furnace)	

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                          INDUSTRIAL PROCESS, PRIMARY METALS                          PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976    RUN DATE= MAR 22,1977
  MODIFIED       TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC       (SCC UNITS)        NOX            HC              CO              PART
303008000                     NEGLIGIBLE     NEGLIGIBLE         7.020            .486
303009000     147490000.         .010           .008            4.271            .093
303010000       6742000.         .000           .000          NEGLIGIBLE         .012
303011000                     NEGLIGIBLE     NEGLIGIBLE       NEGLIGIBLE         .013
303012000         65000.      NEGLIGIBLE     NEGLIGIBLE          .002          NEGLIGIBLE
303030000       1554000.      NEGLIGIBLE     NEGLIGIBLE       NEGLIGIBLE         .005
303999000      31200000.         .001           .001             .002            .047
```

MSCC	Source Category	Charge Rate Unit[a]
303008000	Iron production	N.A.
303009000	Steel production	Tons/yr
303010000	Lead smelters	N.A.
303011000	Molybdenum	N.A.
303012000	Titanium	N.A.
303030000	Zinc smelting	Tons/yr
303999000	Miscellaneous metallurgical processes	Tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976      RUN DATE= MAR 22,1977
 MODIFIED        TACRP                     EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)          NOX            HC             CO            PART
306000000                          .522           .417         16.091          .291

306001000                          .471           .047           .035          .092
306002000        1538000.          .051           .172         15.863          .171
306003000         100800.    NEGLIGIBLE           .005           .194    NEGLIGIBLE
306008000       26970000.    NEGLIGIBLE           .193     NEGLIGIBLE    NEGLIGIBLE
306012000         112000.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE          .027
```

MSCC	Source Category	Charge Rate Unit[a]
306000000	Petroleum Industry	
306001000	Process heater	N.A.
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	1000 bbl capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

```
                          HYDROCARBCN EVAPORATION                        PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976       RUN DATE= MAR 22,1977
                                       EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED         TACRP                                                    PART
  SCC        (SCC UNITS)        NOX            HC         CO
                                                                          .010
400000000                   NEGLIGIBLE       4.238     NEGLIGIBLE
                                                                    NEGLIGIBLE
401000000                   NEGLIGIBLE        .132     NEGLIGIBLE
                                                                    NEGLIGIBLE
401001000          41850.   NEGLIGIBLE        .004     NEGLIGIBLE   NEGLIGIBLE
401002000         114460.   NEGLIGIBLE        .103     NEGLIGIBLE   NEGLIGIBLE
401999000         115650.   NEGLIGIBLE        .025     NEGLIGIBLE   NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
400000000	Point Source Evaporation	N. A.
401000000	Cleaning Solvents	N. A.
401001000	Dry cleaning	Clothes, tons/yr
401002000	Degreasing	Solvent, tons/yr
401999000	Miscellaneous solvent use	Solvent, tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

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                         HYDROCARBON EVAPORATION                         PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976     RUN DATE: MAR 22,1977
                                          EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED        TACRP                                                        PART
  SCC        (SCC UNITS)        NOX              HC          CO
402000000     15354000.     NEGLIGIBLE        2.076      NEGLIGIBLE         .010

402001000       438000.     NEGLIGIBLE         .224      NEGLIGIBLE    NEGLIGIBLE
402002000     10136000.     NEGLIGIBLE         .441      NEGLIGIBLE    NEGLIGIBLE
402003000       274170.     NEGLIGIBLE         .181      NEGLIGIBLE    NEGLIGIBLE
402004000        75735.     NEGLIGIBLE         .056      NEGLIGIBLE    NEGLIGIBLE
402005000       298340.     NEGLIGIBLE         .172      NEGLIGIBLE    NEGLIGIBLE
402006000       876030.     NEGLIGIBLE         .467      NEGLIGIBLE    NEGLIGIBLE
402007000      1583700.     NEGLIGIBLE         .229      NEGLIGIBLE    NEGLIGIBLE
402008000       170640.     NEGLIGIBLE         .104      NEGLIGIBLE    NEGLIGIBLE
402999000      1500900.     NEGLIGIBLE         .202      NEGLIGIBLE         .010
```

MSCC	Source Category	Charge Rate Unit
402000000	Surface Coating	Coating, tons/yr
402001000	Paint	Coating, tons/yr
402002000	Paper coatings	Coating, tons/yr
402003000	Varnish and shellac	Coating, tons/yr
402004000	Lacquer	Coating, tons/yr
402005000	Enamel	Coating, tons/yr
402006000	Primer	Coating, tons/yr
402007000	Fabric coatings	Coating, tons/yr
402008000	Oven coatings	Coating, tons/yr
402999000	Miscellaneous coatings	Coating, tons/yr

Table 1-10-a. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES (Continued)

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                              HYDROCARBON EVAPORATION                    PAGE  3
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976       RUN DATE= MAR 22,1977
 MODIFIED        TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)        NOX          HC           CO          PART
403000000                    NEGLIGIBLE     1.652     NEGLIGIBLE   NEGLIGIBLE

403001000                    NEGLIGIBLE     1.318     NEGLIGIBLE   NEGLIGIBLE
403002000                    NEGLIGIBLE      .200     NEGLIGIBLE   NEGLIGIBLE
403003000       14860000.    NEGLIGIBLE      .065     NEGLIGIBLE   NEGLIGIBLE
403999000       15000000.    NEGLIGIBLE      .069     NEGLIGIBLE   NEGLIGIBLE

406000000      200530000.    NEGLIGIBLE      .378     NEGLIGIBLE   NEGLIGIBLE

406001000       81932000.    NEGLIGIBLE      .237     NEGLIGIBLE   NEGLIGIBLE
406002000      118600000.    NEGLIGIBLE      .141     NEGLIGIBLE   NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
403000000	Petroleum Storage	N. A.
403001000	Fixed roof	N. A.
403002000	Floating roof	N. A.
403003000	Variable vapor space	1000 gal/yr
403999000	Miscellaneous storage	1000 gal/yr
406000000	Petroleum Marketing and Transportation	1000 gal/yr
406001000	Rail and truck transportation	1000 gal/yr
406002000	Marine vessel transportation	1000 gal/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY

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                        EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976              RUN DATE= MAR 22,1977
 MODIFIED          TACRP                     EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX              HC               CO              PART
100000000                         +  .498          +  .103          +  .081          +  .526
                                  -  .500          -  .021          -  .056          -  .526
101000000                         +  .463          +  .102          +  .074          +  .482
                                  -  .463          -  .016          -  .050          -  .482
101002000   +    15024000.        +  .416          +  .101          +  .072          +  .482
            -    15024000.        -  .416          -  .015          -  .048          -  .482
101004000   +     2516400.        +  .103          +  .009          +  .014          +  .010
            -     2516400.        -  .103          -  .006          -  .009          -  .010
101005000   +           0.        + 0.000          + 0.000          + 0.000          + 0.000
            -           0.        - 0.000          - 0.000          - 0.000          - 0.000
101006000   +      875870.        +  .176          +  .001          +  .012          +  .007
            -      875870.        -  .176          -  .001          -  .010          -  .007
101007000   +       15220.        +  .000           NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE
            -       15220.        -  .000           NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                         EXTERNAL COMBUSTION, BOILER CATEGORY                        PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976       RUN DATE= MAR 22,1977
 MODIFIED        TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)          NOX            HC              CO             PART

102000000                        + .186        + .017         + .033         + .210
                                 - .189        - .014         - .024         - .210

102002000    +   7378300.        + .089        + .011         + .023         + .209
             -   7378300.        - .089        - .011         - .016         - .209
102004000    +   1213000.        + .101        + .011         + .013         + .014
             -   1213000.        - .101        - .007         - .009         - .014
102005000    +   1049700.        + .066        + .007         + .008         + .008
             -   1049700.        - .066        - .005         - .006         - .008
102006000    +   1226100.        + .108        + .003         + .017         + .011
             -   1226100.        - .116        - .002         - .014         - .011
102007000    +    142990.        + .000        NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
             -    142990.        - .000        NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                            INTERNAL COMBUSTION ENGINES                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
 MODIFIED         TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)          NOX            HC             CO            PART
200000000                       + .396        + .194        + .038        + .025
                                - .144        - .060        - .013        - .009

201000000                       + .379        + .015        + .030        + .024
                                - .126        - .014        - .010        - .008

201001000   +    3339400.       + .372        + .005        + .029        + .024
            -    1125600.       - .124        - .002        - .010        - .008
201002000   +     417950.       + .072        + .002        + .003        + .001
            -     115800.       - .022        - .001        - .000        - .000
201003000   +      15352.       + .003        + .000        + .002        + .001
            -      15352.       - .002        - .000        - .001        - .001
201999000                       + .003        + .014        + .000        + .001
                                - .003        - .014        - .000        - .001
```

MSCC	Source Category	Charge Rate Unit[a]
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                                INTERNAL COMBUSTION ENGINES
                                                                                 PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976                RUN DATE= MAR 22,1977
 MODIFIED           TACRP
   SCC          (SCC UNITS)          EMISSIONS (MILLIONS OF TONS / YEAR)
                                   NOX            HC             CO             PART
202000000
                               +  .116        +  .193        +  .024        +  .005
                               -  .060        -  .058        -  .009        -  .004

202001000       +     27605.   +  .002        +  .000        +  .001        +  .000
                -     27605.   -  .002        -  .000        -  .001        -  .000
202002000       +    623450.   +  .116        +  .031        +  .024        +  .005
                -    192420.   -  .060        -  .017        -  .009        -  .004
202003000       +      1399.   +  .000        +  .000        +  .002        +  .000
                -      1399.   -  .000        -  .000        -  .001        -  .000
202004000       +     26110.   +  .005        +  .000        +  .002        +  .000
                -     26110.   -  .005        -  .000        -  .002        -  .000
202999000       +      7676.   +  .001        +  .191        +  .000        +  .000
                -      7676.   -  .001        -  .055        -  .000        -  .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING                PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976         RUN (ATE= MAR 22,1977
 MODIFIED         TACRP             EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)        NOX            HC             CO           PART
301000000                     NEGLIGIBLE    +  .101      +  .368      NEGLIGIBLE
                              NEGLIGIBLE    -  .101      -  .368      NEGLIGIBLE

301002000  +     231770.      NEGLIGIBLE    +  .029      +  .001      NEGLIGIBLE
           -     231770.      NEGLIGIBLE    -  .029      -  .001      NEGLIGIBLE
301003000  +      33123.      NEGLIGIBLE    +  .004      +  .032      NEGLIGIBLE
           -      33123.      NEGLIGIBLE    -  .004      -  .032      NEGLIGIBLE
301005000  +     226980.      NEGLIGIBLE    +  .072      +  .343      NEGLIGIBLE
           -     226980.      NEGLIGIBLE    -  .072      -  .343      NEGLIGIBLE
301999000  +   17464000.      NEGLIGIBLE    +  .083      +  .129      NEGLIGIBLE
           -   17464000.      NEGLIGIBLE    -  .083      -  .129      NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                      INDUSTRIAL PROCESS, PRIMARY METALS                     PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
MODIFIED       TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC      (SCC UNITS)          NOX              HC               CO            PART
303000000                    + .002           + .018          + 1.293        + .402
                             - .010           - .052          - 1.294        - .294

303001000  +   8828500.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      + .214
           -   3899300.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      - .044
303002000  +    715940.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      + .037
           -    715940.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      - .045
303003000  +  24758000.    + .000           + .018           + .005          + .035
           -  24758000.    - .001           - .051           - .027          - .039
303004000  +    132570.    NEGLIGIBLE       + .001           + .000          + .029
           -    132570.    NEGLIGIBLE       - .001           - .000          - .021
303005000                  NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      + .051
                           NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      - .054
303006000  +    933990.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      + .142
           -    933990.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      - .073
303007000  +    569650.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      + .002
           -    569650.    NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE      - .002
```

MSCC	Source Category	Charge Rate Unit[a]
303000000	Primary Metals	N. A.
303001000	Aluminum reduction	Aluminum, tons/yr
303002000	Aluminum ore calcined	Tons/yr
303003000	Coke metallurgical	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303005000	Copper smelters	N. A.
303006000	Ferroalloy production (open furnace)	Tons/yr
303007000	Ferroalloy production (closed furnace)	

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES NCERTAINTY (Continued)

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                              INDUSTRIAL PROCESS, PRIMARY METALS                          PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
 MODIFIED        TACRP                      EMISSIONS (MILLIONS OF  ONS / YEAR)
   SCC        (SCC UNITS)         NOX               HC                 O             PART
303008000                      NEGLIGIBLE       NEGLIGIBLE        + 1.047          + .297
                               NEGLIGIBLE       NEGLIGIBLE        - 1.047          - .264
303009000   +   12158000.        + .002           + .002          +  .760          + .039
            -   12158000.        - .010           - .008          -  .760          - .042
303010000   +    1010100.        + .000           + .000          NEGLIGIBLE       + .006
            -    1010100.        - .000           - .000          NEGLIGIBLE       - .008
303011000                      NEGLIGIBLE       NEGLIGIBLE        NEGLIGIBLE       + .003
                               NEGLIGIBLE       NEGLIGIBLE        NEGLIGIBLE       - .003
303012000   +       9999.      NEGLIGIBLE       NEGLIGIBLE        +  .001          NEGLIGIBLE
            -       9999.      NEGLIGIBLE       NEGLIGIBLE        -  .001          NEGLIGIBLE
303030000   +     191010.      NEGLIGIBLE       NEGLIGIBLE        NEGLIGIBLE       + .001
            -     191010.      NEGLIGIBLE       NEGLIGIBLE        NEGLIGIBLE       - .001
303999000   +    4386300.        + .000           + .000          +  .000          + .008
            -    4386300.        - .001           - .000          -  .001          - .006
```

MSCC	Source Category	Charge Rate Unit[a]
303008000	Iron production	N. A.
303009000	Steel production	Tons/yr
303010000	Lead smelters	N. A.
303011000	Molybdenum	N. A.
303012000	Titanium	N. A.
303030000	Zinc smelting	Tons/yr
303999000	Miscellaneous metallurgical processes	Tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                  PAGE   1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
 MODIFIED        TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)         NOX              HC               CO             PART
306000000                       + .026          + .037          + 6.047          + .011
                                - .026          - .037          - 6.047          - .011

306001000                       + .026          + .006          +  .005          + .005
                                - .026          - .006          -  .005          - .005
306002000   +       44790.      + .003          + .010          + 6.047          + .010
            -       44790.      - .003          - .010          - 6.047          - .010
306003000   +        4707.     NEGLIGIBLE       + .000          +  .013         NEGLIGIBLE
            -        4707.     NEGLIGIBLE       - .000          -  .013         NEGLIGIBLE
306008000   +      358570.     NEGLIGIBLE       + .035         NEGLIGIBLE       NEGLIGIBLE
            -      358570.     NEGLIGIBLE       - .035         NEGLIGIBLE       NEGLIGIBLE
306012000   +        3225.     NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE        + .002
            -        3225.     NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE        - .002
```

MSCC	Source Category	Charge Rate Unit[a]
306000000	Petroleum Industry	
306001000	Process heater	N.A.
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	1000 bbl capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                              HYDROCARBON EVAPORATION                               PAGE  1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976                         RUN DAT = MAR 22,1977
                                         EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED        TACRP                 NOX              HC            CO              PART
  SCC        (SCC UNITS)
                                                    + .463       NEGLIGIBLE       + .002
400000000                          NEGLIGIBLE       - .454       NEGLIGIBLE       - .002
                                   NEGLIGIBLE
                                                    + .050       NEGLIGIBLE       NEGLIGIBLE
401000000                          NEGLIGIBLE       - .050       NEGLIGIBLE       NEGLIGIBLE
                                   NEGLIGIBLE
                                                    + .004       NEGLIGIBLE       NEGLIGIBLE
401001000    +      23358.         NEGLIGIBLE       - .002       NEGLIGIBLE       NEGLIGIBLE
             -      15367.         NEGLIGIBLE       + .050       NEGLIGIBLE       NEGLIGIBLE
401002000    +      51063.         NEGLIGIBLE       - .050       NEGLIGIBLE       NEGLIGIBLE
             -      51063.         NEGLIGIBLE       + .005       NEGLIGIBLE       NEGLIGIBLE
401999000    +      18320.         NEGLIGIBLE       - .005       NEGLIGIBLE       NEGLIGIBLE
             -      18320.         NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
400000000	Point Source Evaporation	N. A.
401000000	Cleaning Solvents	N. A.
401001000	Dry cleaning	Clothes, tons/yr
401002000	Degreasing	Solvent, tons/yr
401999000	Miscellaneous solvent use	Solvent, tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY
(Continued)

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                          HYDROCARBCN EVAPORATION                          PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976            RUN DATE= MAR 22,1977
 MODIFIED      TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC      (SCC UNITS)        NOX              HC            CO            PART
402000000  +  3233000.     NEGLIGIBLE     +  .269      NEGLIGIBLE     +  .002
           -  3211400.     NEGLIGIBLE     -  .253      NEGLIGIBLE     -  .002

402001000  +    38745.     NEGLIGIBLE     +  .027      NEGLIGIBLE     NEGLIGIBLE
           -    38745.     NEGLIGIBLE     -  .027      NEGLIGIBLE     NEGLIGIBLE
402002000  +  3219300.     NEGLIGIBLE     +  .214      NEGLIGIBLE     NEGLIGIBLE
           -  3197600.     NEGLIGIBLE     -  .196      NEGLIGIBLE     NEGLIGIBLE
402003000  +    26919.     NEGLIGIBLE     +  .019      NEGLIGIBLE     NEGLIGIBLE
           -    26919.     NEGLIGIBLE     -  .019      NEGLIGIBLE     NEGLIGIBLE
402004000  +    11094.     NEGLIGIBLE     +  .010      NEGLIGIBLE     NEGLIGIBLE
           -    11094.     NEGLIGIBLE     -  .010      NEGLIGIBLE     NEGLIGIBLE
402005000  +    44162.     NEGLIGIBLE     +  .026      NEGLIGIBLE     NEGLIGIBLE
           -    44162.     NEGLIGIBLE     -  .026      NEGLIGIBLE     NEGLIGIBLE
402006000  +    87689.     NEGLIGIBLE     +  .093      NEGLIGIBLE     NEGLIGIBLE
           -    87689.     NEGLIGIBLE     -  .093      NEGLIGIBLE     NEGLIGIBLE
402007000  +   106620.     NEGLIGIBLE     +  .119      NEGLIGIBLE     NEGLIGIBLE
           -   106620.     NEGLIGIBLE     -  .119      NEGLIGIBLE     NEGLIGIBLE
402008000  +    27605.     NEGLIGIBLE     +  .018      NEGLIGIBLE     NEGLIGIBLE
           -    27605.     NEGLIGIBLE     -  .018      NEGLIGIBLE     NEGLIGIBLE
402999000  +   253400.     NEGLIGIBLE     +  .040      NEGLIGIBLE     +  .002
           -   253400.     NEGLIGIBLE     -  .040      NEGLIGIBLE     -  .002
```

MSCC	Source Category	Charge Rate Unit
402000000	Surface Coating	Coating, tons/yr
402001000	Paint	Coating, tons/yr
402002000	Paper coatings	Coating, tons/yr
402003000	Varnish and shellac	Coating, tons/yr
402004000	Lacquer	Coating, tons/yr
402005000	Enamel	Coating, tons/yr
402006000	Primer	Coating, tons/yr
402007000	Fabric coatings	Coating, tons/yr
402008000	Oven coatings	Coating, tons/yr
402999000	Miscellaneous coatings	Coating, tons/yr

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                                  HYDROCARBON EVAPORATION                                PAGE   3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976                    RUN DATE= MAR 22,1977
  MODIFIED         TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC         (SCC UNITS)         NOX            HC              CO              PART
 403000000                       NEGLIGIBLE   +  .362         NEGLIGIBLE      NEGLIGIBLE
                                 NEGLIGIBLE   -  .362         NEGLIGIBLE      NEGLIGIBLE

 403001000                       NEGLIGIBLE   +  .352         NEGLIGIBLE      NEGLIGIBLE
                                 NEGLIGIBLE   -  .351         NEGLIGIBLE      NEGLIGIBLE
 403002000                       NEGLIGIBLE   +  .079         NEGLIGIBLE      NEGLIGIBLE
                                 NEGLIGIBLE   -  .075         NEGLIGIBLE      NEGLIGIBLE
 403003000      +    371080.     NEGLIGIBLE   +  .011         NEGLIGIBLE      NEGLIGIBLE
                -    371080.     NEGLIGIBLE   -  .011         NEGLIGIBLE      NEGLIGIBLE
 403999000      +   8246200.     NEGLIGIBLE   +  .039         NEGLIGIBLE      NEGLIGIBLE
                -   8246200.     NEGLIGIBLE   -  .047         NEGLIGIBLE      NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
403000000	Petroleum Storage	N. A.
403001000	Fixed roof	N. A.
403002000	Floating roof	N. A.
403003000	Variable vapor space	1000 gal/yr
403999000	Miscellaneous storage	1000 gal/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-10-b. SUMMARY OF 1976 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                              HYDROCARBON EVAPORATION
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976                           PAGE  4
MODIFIED        TACRP                                               RUN DATE= MAR 22,1977
  SCC        (SCC UNITS)             EMISSIONS (MILLIONS OF TONS / YEAR)
                                  NOX                HC           CO              PART
406000000  +   17011000.      NEGLIGIBLE         +  .087      NEGLIGIBLE      NEGLIGIBLE
           -   17011000.      NEGLIGIBLE         -  .088      NEGLIGIBLE      NEGLIGIBLE
406001000  +    7161400.      NEGLIGIBLE         +  .082      NEGLIGIBLE      NEGLIGIBLE
           -    7161400.      NEGLIGIBLE         -  .082      NEGLIGIBLE      NEGLIGIBLE
406002000  +   15430000.      NEGLIGIBLE         +  .028      NEGLIGIBLE      NEGLIGIBLE
           -   15430000.      NEGLIGIBLE         -  .031      NEGLIGIBLE      NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
406000000	Petroleum Marketing and Transportation	1000 gal/yr
406001000	Rail and truck transportation	1000 gal/yr
406002000	Marine vessel transportation	1000 gal/yr

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES

```
                    EXTERNAL COMBUSTION, BOILER CATEGORY                         PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
MODIFIED            TACRP                     EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC            (SCC UNITS)        NOX            HC            CO           PART
100000000                          5.877          .195          .457          5.620
101000000                          4.786          .115          .300          4.057
101002000        474040000.        4.609          .085          .242          3.929
101004000         28590000.         .120          .029          .043           .114
101005000               0.         0.000         0.000         0.000          0.000
101006000          1785600.         .057          .001          .015           .013
101007000            90390.         .000    NEGLIGIBLE    NEGLIGIBLE     NEGLIGIBLE
102000000                          1.091          .081          .157          1.563
102002000        100540000.         .816          .040          .089          1.290
102004000         16000000.         .096          .024          .032           .184
102005000          9340000.         .056          .014          .019           .070
102006000          2080000.         .123          .003          .018           .019
102007000          1749300.         .000    NEGLIGIBLE    NEGLIGIBLE     NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                          INTERNAL COMBUSTION ENGINES                             PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981           RUN DATE= MAR 22,1977
 MODIFIED         TACRP                  EMISSIONS  (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)        NOX            HC             CO              PART
200000000                        .560          .432           .065             .018

201000000                        .257          .107           .019             .013

201001000       1313100.         .145          .002           .012             .009
201002000        280980.         .080          .000           .000             .000
201003000         84459.         .012          .001           .005             .002
201999000                        .020          .104           .002             .002
```

MSCC	Source Category	Charge Rate Unit[a]
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                              INTERNAL COMBUSTION ENGINES                             PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981          RUN D TE= MAR 22,1977
 MODIFIED      TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC      (SCC UNITS)          NOX              HC              CO               PART
202000000                        .304             .325            .046             .005

202001000         82513.         .005             .000            .002             .001
202002000        794600.         .286             .073            .036             .003
202003000          4859.         .001             .001            .004             .000
202004000         37511.         .007             .001            .003             .000
202999000         34742.         .005             .250            .001             .000
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                    PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED       TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC       (SCC UNITS)        NOX            HC            CO           PART
301000000                   NEGLIGIBLE       1.135         2.788       NEGLIGIBLE

301002000        7278400.   NEGLIGIBLE        .250          .003       NEGLIGIBLE
301003000        2910400.   NEGLIGIBLE        .037          .035       NEGLIGIBLE
301005000        6250600.   NEGLIGIBLE        .330         2.394       NEGLIGIBLE
301999000      151180000.   NEGLIGIBLE        .518          .336       NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RAT1 (Continued)

```
                         INDUSTRIAL PROCESS, PRIMARY METALS                           PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP                  EMISSIONS (MILLIONS OF  ONS / YEAR)
   SCC          (SCC UNITS)        NOX             HC              CO                PART
303000000                          .013            .198            6.657             .710
303001000         23362000.    NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE            .039
303002000          9374000.    NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE            .009
303003000        458400000.        .002            .184            .056              .032
303004000          1390000.    NEGLIGIBLE          .006            .001              .056
303005000                      NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE            .312
303006000          4127300.    NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE            .030
303007000          2680000.    NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE            .001
```

MSCC	Source Category	Charge Rate Unit[a]
303000000	Primary Metals	N. A.
303001000	Aluminum reduction	Aluminum, tons/yr
303002000	Aluminum ore calcined	Tons/yr
303003000	Coke metallurgical	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303005000	Copper smelters	N. A.
303006000	Ferroalloy production (open furnace)	Tons/yr
303007000	Ferroalloy production (closed furnace)	

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                         INDUSTRIAL PROCESS, PRIMARY METALS                              PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED        TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)        NOX              HC              CO             PART
303008000                     NEGLIGIBLE      NEGLIGIBLE         4.510            .144
303009000     135420000.         .010            .008            2.087            .021
303010000       6932000.         .000            .000         NEGLIGIBLE          .004
303011000                     NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE          .007
303012000         65000.      NEGLIGIBLE      NEGLIGIBLE          .000         NEGLIGIBLE
303030000       1556000.      NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE          .002
303999000      35200000.         .002            .001            .002             .053
```

MSCC	Source Category	Charge Rate Unit[a]
303008000	Iron production	N.A.
303009000	Steel production	Tons/yr
303010000	Lead smelters	N.A.
303011000	Molybdenum	N.A.
303012000	Titanium	N.A.
303030000	Zinc smelting	Tons/yr
303999000	Miscellaneous metallurgical processes	Tons/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES ontinued)

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               INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                   PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED        TACRP            EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC       (SCC UNITS)        NOX           HC            CO           PART
306000000                       .347          .462        10.321         .224

306001000                       .290          .058          .039         .079
306002000      1728000.         .058          .182        10.168         .115
306003000        62300.    NEGLIGIBLE         .003          .115    NEGLIGIBLE
306008000     30570000.    NEGLIGIBLE         .221    NEGLIGIBLE    NEGLIGIBLE
306012000       122000.    NEGLIGIBLE   NEGLIGIBLE    NEGLIGIBLE         .030
```

MSCC	Source Category	Charge Rate Unit[a]
306000000	Petroleum Industry	
306001000	Process heater	N.A.
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl/yr
306008000	Miscellaneous leakage	1000 bbl capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                         HYDROCARBON EVAPORATION                     PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
                                 EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED       TACRP                                                     PART
  SCC       (SCC UNITS)        NOX          HC          CO
400000000                   NEGLIGIBLE    2.425     NEGLIGIBLE         .012
401000000                   NEGLIGIBLE     .111     NEGLIGIBLE    NEGLIGIBLE
401001000        43000.     NEGLIGIBLE     .001     NEGLIGIBLE    NEGLIGIBLE
401002000       114560.     NEGLIGIBLE     .096     NEGLIGIBLE    NEGLIGIBLE
401999000       130690.     NEGLIGIBLE     .014     NEGLIGIBLE    NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
400000000	Point Source Evaporation	N. A.
401000000	Cleaning Solvents	N. A.
401001000	Dry cleaning	Clothes, tons/yr
401002000	Degreasing	Solvent, tons/yr
401999000	Miscellaneous solvent use	Solvent, tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                                   HYDROCARBON EVAPORATION                              PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981                      RUN DATE. MAR 22,1977
                                              EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP
   SCC         (SCC UNITS)          NOX             HC           CO               PART

402000000      12989000.        NEGLIGIBLE        1.506      NEGLIGIBLE            .012

402001000        601620.        NEGLIGIBLE         .145      NEGLIGIBLE         NEGLIGIBLE
402002000       6842900.        NEGLIGIBLE         .289      NEGLIGIBLE         NEGLIGIBLE
402003000        401970.        NEGLIGIBLE         .133      NEGLIGIBLE         NEGLIGIBLE
402004000         97988.        NEGLIGIBLE         .036      NEGLIGIBLE         NEGLIGIBLE
402005000        382350.        NEGLIGIBLE         .110      NEGLIGIBLE         NEGLIGIBLE
402006000       1294500.        NEGLIGIBLE         .344      NEGLIGIBLE         NEGLIGIBLE
402007000       1652700.        NEGLIGIBLE         .239      NEGLIGIBLE         NEGLIGIBLE
402008000        220940.        NEGLIGIBLE         .067      NEGLIGIBLE         NEGLIGIBLE
402999000       1693600.        NEGLIGIBLE         .143      NEGLIGIBLE            .012
```

MSCC	Source Category	Charge Rate Unit
402000000	Surface Coating	Coating, tons/yr
402001000	Paint	Coating, tons/yr
402002000	Paper coatings	Coating, tons/yr
402003000	Varnish and shellac	Coating, tons/yr
402004000	Lacquer	Coating, tons/yr
402005000	Enamel	Coating, tons/yr
402006000	Primer	Coating, tons/yr
402007000	Fabric coatings	Coating, tons/yr
402008000	Oven coatings	Coating, tons/yr
402999000	Miscellaneous coatings	Coating, tons/yr

Table 1-11-a. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES (Continued)

```
                              HYDROCARBCN EVAPORATION                  PAGE  3
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED          TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)      NOX            HC            CO            PART
403000000                     NEGLIGIBLE       .505      NEGLIGIBLE    NEGLIGIBLE

403001000                     NEGLIGIBLE       .082      NEGLIGIBLE    NEGLIGIBLE
403002000                     NEGLIGIBLE       .212      NEGLIGIBLE    NEGLIGIBLE
403003000          32360000.  NEGLIGIBLE       .142      NEGLIGIBLE    NEGLIGIBLE
403999000          15000000.  NEGLIGIBLE       .069      NEGLIGIBLE    NEGLIGIBLE

406000000         196900000.  NEGLIGIBLE       .303      NEGLIGIBLE    NEGLIGIBLE

406001000          83302000.  NEGLIGIBLE       .090      NEGLIGIBLE    NEGLIGIBLE
406002000         113600000.  NEGLIGIBLE       .213      NEGLIGIBLE    NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit[a]
403000000	Petroleum Storage	N. A.
403001000	Fixed roof	N. A.
403002000	Floating roof	N. A.
403003000	Variable vapor space	1000 gal/yr
403999000	Miscellaneous storage	1000 gal/yr
406000000	Petroleum Marketing and Transportation	1000 gal/yr
406001000	Rail and truck transportation	1000 gal/yr
406002000	Marine vessel transportation	1000 gal/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY

```
                          EXTERNAL COMBUSTION, BOILER CATEGORY                    PAGE  1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981                   RUN DATE= MAR 22,1977

                                          EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED         TACRP                                                               PART
  SCC        (SCC UNITS)          NOX           HC              CO
                                                 + .126         + .105           + .971
100000000                       + .954           - .030         - .070           - .971
                                - .899
                                                 + .123         + .092           + .913
101000000                       + .894           - .020         - .062           - .913
                                - .873
                                                                + .087           + .913
101002000    +    34654000.     + .872           + .123         - .059           - .913
             -    34654000.     - .872           - .018         + .020           + .021
101004000    +     5192100.     + .178           + .013         - .014           - .021
             -     5192100.     - .023           - .010         + 0.000          + 0.000
101005000    +           0.     + 0.000          + 0.000        - 0.000          - 0.000
             -           0.     - 0.000          - 0.000        + .321           + .017
101006000    +     7318500.     + .083           + .001         - .009           - .008
             -     1003200.     - .032           - .001       NEGLIGIBLE       NEGLIGIBLE
101007000    +       15220.     + .000        NEGLIGIBLE      NEGLIGIBLE       NEGLIGIBLE
             -       15220.     - .000        NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
100000000	External Combustion (Boiler)	
101000000	Electric Generation	
101002000	Bituminous coal	Tons burned/yr
101004000	Residual oil	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101007000	Process gas	Million cu ft/yr

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                    EXTERNAL COMBUSTION, BOILER CATEGORY                       PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
 MODIFIED          TACRP                     EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX              HC               CO              PART

102000000                         + .334          + .025           + .050           + .329
                                  - .216          - .021           - .033           - .330

102002000    +   14080000.        + .197          + .018           + .037           + .327
             -   14080000.        - .197          - .018           - .027           - .328
102004000    +    1832900.        + .165          + .013           + .016           + .021
             -    1832900.        - .029          - .009           - .012           - .021
102005000    +    2344200.        + .105          + .009           + .011           + .018
             -    2344200.        - .022          - .006           - .009           - .018
102006000    +    3013100.        + .166          + .005           + .027           + .027
             -    1373000.        - .081          - .002           - .012           - .012
102007000    +     142990.        + .000        NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE
             -     142990.        - .000        NEGLIGIBLE       NEGLIGIBLE       NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
102000000	Industrial	
102002000	Bituminous coal	Tons burned/yr
102004000	Residual oil	1000 gal/yr
102005000	Distillate oil	1000 gal/yr
102006000	Natural gas	Million cu ft/yr
102007000	Process gas	Million cu ft/yr

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                            INTERNAL COMBUSTION ENGINES                              PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981              RUN DATE= MAR 22,1977
                                              EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED          TACRP                   NOX                HC               CO              PART
  SCC          (SCC UNITS)

200000000                            +  .425          +  .279          +  .041         +  .026
                                     -  .184          -  .127          -  .018         -  .010

201000000                            +  .399          +  .030          +  .031         +  .026
                                     -  .147          -  .029          -  .012         -  .010

201001000     +      3518700.        +  .392          +  .005          +  .031         +  .026
              -      1313100.        -  .145          -  .002          -  .012         -  .009
201002000     +       420260.        +  .074          +  .002          +  .003         +  .001
              -       108180.        -  .024          -  .000          -  .000         -  .000
201003000     +        19658.        +  .003          +  .000          +  .002         +  .001
              -        19658.        -  .003          -  .000          -  .001         -  .001
201999000                            +  .006          +  .029          +  .001         +  .002
                                     -  .006          -  .029          -  .001         -  .002
```

MSCC	Source Category	Charge Rate Unit[a]
200000000	Internal Combustion	
201000000	Electric Generation	
201001000	Distillate oil	1000 gal/yr
201002000	Natural gas	Million cu ft/yr
201003000	Diesel	1000 gal/yr
201999000	Miscellaneous fuel	N.A.

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[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                         INTERNAL COMBUSTION ENGINES                              PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981                    RUN DATE= MAR 22,1977
                                      EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED           TACRP
  SCC          (SCC UNITS)          NOX          HC             CO            PART
                                                + .277         + .027         + .005
202000000                         + .146        - .123         - .014         - .003
                                  - .111
                                                + .000         + .001         + .001
202001000      +    54926.        + .003        - .000         - .001         - .001
               -    54926.        - .003        + .038         + .027         + .005
202002000      +   674550.        + .146        - .028         - .014         - .003
               -   299230.        - .110        + .000         + .003         + .000
202003000      +     2540.        + .000        - .000         - .002         - .000
               -     2540.        - .000        + .000         + .002         + .000
202004000      +    26568.        + .005        - .000         - .002         - .000
               -    26568.        - .005        + .275         + .001         + .000
202999000      +    16652.        + .002        - .120         - .001         - .000
               -    16652.        - .002
```

MSCC	Source Category	Charge Rate Unit
202000000	Industrial IC Engines	
202001000	Distillate oil turbine	1000 gal/yr
202002000	Distillate oil reciprocating	1000 gal/yr
202003000	Natural gas turbine	Million cu ft/yr
202004000	Natural gas reciprocating	Million cu ft/yr
202999000	Miscellaneous fuels[a]	Million cu ft/yr

[a] Although this category is made up of two MSCCs whose units are different, only one (202999970) was studied.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
              INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING                   PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN D/TE= MAR 22,1977
 MODIFIED        TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)           NOX            HC            CO            PART

301000000                        NEGLIGIBLE     + .118        + .458        NEGLIGIBLE
                                 NEGLIGIBLE     - .117        - .452        NEGLIGIBLE

301002000   +      311020.       NEGLIGIBLE     + .034        + .001        NEGLIGIBLE
            -      311020.       NEGLIGIBLE     - .034        - .001        NEGLIGIBLE
301003000   +       74077.       NEGLIGIBLE     + .005        + .037        NEGLIGIBLE
            -       74077.       NEGLIGIBLE     - .005        - .037        NEGLIGIBLE
301005000   +      241910.       NEGLIGIBLE     + .093        + .430        NEGLIGIBLE
            -      241200.       NEGLIGIBLE     - .091        - .431        NEGLIGIBLE
301999000   +    17464000.       NEGLIGIBLE     + .065        + .129        NEGLIGIBLE
            -    17464000.       NEGLIGIBLE     - .065        - .129        NEGLIGIBLE
```

MSCC	Source Category	Charge Rate Unit
300000000	Industrial Processes	
301000000	Chemical Manufacturing	
301002000	Ammonia production with methanator	Tons/yr
301003000	Ammonia production with CO absorber	Tons/yr
301005000	Carbon black production	Tons/yr
301999000	Miscellaneous chemical manufacturing	Tons/yr

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                    INDUSTRIAL PROCESS, PRIMARY METALS                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981              RUN DATE= MAR 22,1977
                                     EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP
   SCC         (SCC UNITS)        NOX            HC              CO            PART

303000000                      + .003         + .043          + 3.647        + .151
                               - .010         - .116          - 2.575        - .124

303001000   +   8970700.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      + .096
            -   4222000.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      - .022
303002000   +    779610.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      + .008
            -    779610.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      - .009
303003000   +  68177000.       + .000         + .042          + .012         + .011
            -  68177000.       - .001         - .116          - .034         - .011
303004000   +    158690.      NEGLIGIBLE      + .001          + .000         + .056
            -    158690.      NEGLIGIBLE      - .003          - .000         - .056
303005000                     NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      + .076
                              NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      - .076
303006000   +   1595700.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      + .026
            -   1586000.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      - .018
303007000   +    952170.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      + .001
            -    952170.      NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE      - .001
```

MSCC	Source Category	Charge Rate Unit[a]
303000000	Primary Metals	N. A.
303001000	Aluminum reduction	Aluminum, tons/yr
303002000	Aluminum ore calcined	Tons/yr
303003000	Coke metallurgical	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303005000	Copper smelters	N. A.
303006000	Ferroalloy production (open furnace)	Tons/yr
303007000	Ferroalloy production (closed furnace)	

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                      INDUSTRIAL PROCESS, PRIMARY METALS                         PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
 MODIFIED        TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)         NOX            HC             CO            PART
303008000                      NEGLIGIBLE     NEGLIGIBLE     + 2.395        +  .058
                               NEGLIGIBLE     NEGLIGIBLE     - 1.870        -  .071
303009000    +  20216000.      +  .003        +  .003        + 2.750        +  .010
             -  20216000.      -  .010        -  .008        - 1.769        -  .017
303010000    +   1629200.      +  .000        +  .000        NEGLIGIBLE     +  .003
             -   1629200.      -  .000        -  .000        NEGLIGIBLE     -  .003
303011000                      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .004
                               NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .004
303012000    +     18973.      NEGLIGIBLE     NEGLIGIBLE     +  .003        NEGLIGIBLE
             -     18973.      NEGLIGIBLE     NEGLIGIBLE     -  .000        NEGLIGIBLE
303030000    +    341090.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .001
             -    341090.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .001
303999000    +   7800000.      +  .000        +  .000        +  .000        +  .013
             -   7800000.      -  .002        -  .001        -  .002        -  .013
```

MSCC	Source Category	Charge Rate Unit[a]
303008000	Iron production	N. A.
303009000	Steel production	Tons/yr
303010000	Lead smelters	N. A.
303011000	Molybdenum	N. A.
303012000	Titanium	N. A.
303030000	Zinc smelting	Tons/yr
303999000	Miscellaneous metallurgical processes	Tons/yr

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[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

```
                                                                        PAGE  1
                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
                                         EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED        TACRP
   SCC        (SCC UNITS)         NOX           HC            CO          PART
306000000                      + .034       + .049       + 6.877       + .017
                               - .034       - .049       - 6.877       - .017

306001000                      + .034       + .007       +  .007       + .007
                               - .034       - .007       -  .007       - .007
306002000   +     201800.      + .007       + .023       + 6.877       + .015
            -     201800.      - .007       - .023       - 6.877       - .015
306003000   +      25161.     NEGLIGIBLE    + .001       +  .047      NEGLIGIBLE
            -      25161.     NEGLIGIBLE    - .001       -  .047      NEGLIGIBLE
306008000   +    1642900.     NEGLIGIBLE    + .042      NEGLIGIBLE    NEGLIGIBLE
            -    1642900.     NEGLIGIBLE    - .043      NEGLIGIBLE    NEGLIGIBLE
306012000   +      14323.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     + .004
            -      14323.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     - .004
```

MSCC	Source Category	Charge Rate Unit[a]
306000000	Petroleum Industry	N.A.
306001000	Process heater	1000 bbl/yr
306002000	Fluid catalytic crackers	1000 bbl/yr
306003000	Moving bed catalytic crackers	1000 bbl
306008000	Miscellaneous leakage	capacity/yr
306012000	Fluid coking	1000 bbl feed/yr

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[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                               HYDROCARBON EVAPORATION                                     PAGE  1
                                                                             RUN DATE= MAR 22,1977
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981
                                         EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP                                  HC                CO                 PART
   SCC         (SCC UNITS)          NOX
                                 NEGLIGIBLE      +   .580        NEGLIGIBLE         +   .003
400000000                        NEGLIGIBLE      -   .459        NEGLIGIBLE         -   .003

                                 NEGLIGIBLE      +   .094        NEGLIGIBLE          NEGLIGIBLE
401000000                        NEGLIGIBLE      -   .089        NEGLIGIBLE          NEGLIGIBLE

                                                                 NEGLIGIBLE          NEGLIGIBLE
401001000     +        33470.    NEGLIGIBLE      +   .006        NEGLIGIBLE          NEGLIGIBLE
              -        20053.    NEGLIGIBLE      -   .001        NEGLIGIBLE          NEGLIGIBLE
401002000     +       100730.    NEGLIGIBLE      +   .093        NEGLIGIBLE          NEGLIGIBLE
              -        97631.    NEGLIGIBLE      -   .088        NEGLIGIBLE          NEGLIGIBLE
401999000     +        32003.    NEGLIGIBLE      +   .015        NEGLIGIBLE          NEGLIGIBLE
              -        32003.    NEGLIGIBLE      -   .014
```

MSCC	Source Category	Charge Rate Unit[a]
400000000	Point Source Evaporation	N. A.
401000000	Cleaning Solvents	N. A.
401001000	Dry cleaning	Clothes, tons/yr
401002000	Degreasing	Solvent, tons/yr
401999000	Miscellaneous solvent use	Solvent, tons/yr

[a] N. A. (not applicable) is listed under "Charge Rate Unit" where the MSCC number is made up of two or more MSCCs whose charge rates are different.

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

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                                HYDROCARBON EVAPORATION                          PAGE  2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
MODIFIED           TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC           (SCC UNITS)         NOX                HC            CO             PART
402000000   +     6845000.      NEGLIGIBLE      +   .518       NEGLIGIBLE       +   .003
            -     6138800.      NEGLIGIBLE      -   .402       NEGLIGIBLE       -   .003

402001000   +       76850.      NEGLIGIBLE      +   .138       NEGLIGIBLE       NEGLIGIBLE
            -       76850.      NEGLIGIBLE      -   .105       NEGLIGIBLE       NEGLIGIBLE
402002000   +     6826800.      NEGLIGIBLE      +   .260       NEGLIGIBLE       NEGLIGIBLE
            -     6118500.      NEGLIGIBLE      -   .146       NEGLIGIBLE       NEGLIGIBLE
402003000   +       51220.      NEGLIGIBLE      +   .129       NEGLIGIBLE       NEGLIGIBLE
            -       51220.      NEGLIGIBLE      -   .106       NEGLIGIBLE       NEGLIGIBLE
402004000   +       23345.      NEGLIGIBLE      +   .027       NEGLIGIBLE       NEGLIGIBLE
            -       23345.      NEGLIGIBLE      -   .021       NEGLIGIBLE       NEGLIGIBLE
402005000   +       94088.      NEGLIGIBLE      +   .080       NEGLIGIBLE       NEGLIGIBLE
            -       94088.      NEGLIGIBLE      -   .066       NEGLIGIBLE       NEGLIGIBLE
402006000   +      167120.      NEGLIGIBLE      +   .362       NEGLIGIBLE       NEGLIGIBLE
            -      167120.      NEGLIGIBLE      -   .273       NEGLIGIBLE       NEGLIGIBLE
402007000   +      106980.      NEGLIGIBLE      +   .124       NEGLIGIBLE       NEGLIGIBLE
            -      106980.      NEGLIGIBLE      -   .168       NEGLIGIBLE       NEGLIGIBLE
402008000   +       38852.      NEGLIGIBLE      +   .052       NEGLIGIBLE       NEGLIGIBLE
            -       38852.      NEGLIGIBLE      -   .052       NEGLIGIBLE       NEGLIGIBLE
402999000   +      432910.      NEGLIGIBLE      +   .095       NEGLIGIBLE       +   .003
            -      432910.      NEGLIGIBLE      -   .095       NEGLIGIBLE       -   .003
```

MSCC	Source Category	Charge Rate Unit
402000000	Surface Coating	Coating, tons/yr
402001000	Paint	Coating, tons/yr
402002000	Paper coatings	Coating, tons/yr
402003000	Varnish and shellac	Coating, tons/yr
402004000	Lacquer	Coating, tons/yr
402005000	Enamel	Coating, tons/yr
402006000	Primer	Coating, tons/yr
402007000	Fabric coatings	Coating, tons/yr
402008000	Oven coatings	Coating, tons/yr
402999000	Miscellaneous coatings	Coating, tons/yr

Table 1-11-b. SUMMARY OF 1981 EMISSIONS AND CHARGE RATES UNCERTAINTY (Continued)

HYDROCARBON EVAPORATION PAGE 3

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE: MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
403000000			NEGLIGIBLE	+	.163	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.167	NEGLIGIBLE	NEGLIGIBLE
403001000			NEGLIGIBLE	+	.015	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.030	NEGLIGIBLE	NEGLIGIBLE
403002000			NEGLIGIBLE	+	.137	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.128	NEGLIGIBLE	NEGLIGIBLE
403003000	+	814980.	NEGLIGIBLE	+	.025	NEGLIGIBLE	NEGLIGIBLE
	-	814980.	NEGLIGIBLE	-	.077	NEGLIGIBLE	NEGLIGIBLE
403999000	+	18111000.	NEGLIGIBLE	+	.084	NEGLIGIBLE	NEGLIGIBLE
	-	15000000.	NEGLIGIBLE	-	.069	NEGLIGIBLE	NEGLIGIBLE
406000000	+	40178000.	NEGLIGIBLE	+	.178	NEGLIGIBLE	NEGLIGIBLE
	-	20607000.	NEGLIGIBLE	-	.116	NEGLIGIBLE	NEGLIGIBLE
406001000	+	15906000.	NEGLIGIBLE	+	.152	NEGLIGIBLE	NEGLIGIBLE
	-	16082000.	NEGLIGIBLE	-	.036	NEGLIGIBLE	NEGLIGIBLE
406002000	+	36096000.	NEGLIGIBLE	+	.094	NEGLIGIBLE	NEGLIGIBLE
	-	15046000.	NEGLIGIBLE	-	.102	NEGLIGIBLE	NEGLIGIBLE

MSCC	Source Category	Charge Rate Unit[a]
403000000	Petroleum Storage	N.A.
403001000	Fixed roof	N.A.
403002000	Floating roof	N.A.
403003000	Variable vapor space	1000 gal/yr
403999000	Miscellaneous storage	1000 gal/yr
406000000	Petroleum Marketing and Transportation	1000 gal/yr
406001000	Rail and truck transportation	1000 gal/yr
406002000	Marine vessel transportation	1000 gal/yr

[a] N.A. (not applicable) is listed under "Charge Rate Unit" where the MSCC

1.4 DATA ACQUISITION

1.4.1 Data Selected for Study

It was determined at the outset, by EPA, that this study would be restricted to stationary sources of emissions and that the emissions of interest were oxides of nitrogen (NO_x), carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PART). It was also agreed that only point sources (as opposed to area sources) of emissions would be studied. A point source, as defined by the National Emissions Data System (NEDS), is a single stack or geographical point from which more than 100 tons of a given identified air pollutant are discharged annually into the atmosphere. The NEDS is described in detail in Ref. 1-1. The processes which contribute to the atmospheric emissions studied and reported here are described in Refs. 1-2 and 1-3.

The categories of emission sources initially selected for study were determined from the NEDS nationwide emissions report (Ref. 1-4). The order of priority was based largely on the desire to study as many stationary sources of the four emissions in as little time as possible. Table 1-12 shows the emissions from the categories selected for study. The values are as reported in the NEDS Nationwide Emissions Summary, January 10, 1975 (Ref. 1-4).

Table 1-12 shows that stationary area sources represent from 13 to 30 percent of the emissions of interest. The categories selected for study represent from 78 to 100 percent of the four point source emissions identified in Ref. 1-4.

Of the categories inventoried in the first year of this study, utility and industrial boilers and process gas combustion were studied together and are reported in Section II under the more general category "external combustion (boiler)." The process gas combustion category was included in this study because an earlier NEDS nationwide emissions summary (emissions as of December 19, 1973) indicated that nearly

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Table 1-12. STUDY LIST OF EMISSIONS[a]

Source Category	Percent of Total Stationary Source Emissions			
	NO_x	HC	CO	PART
Utility Boilers	48.4	0.8	0.8	23.1
Industrial Boilers	9.6	0.9	1.0	9.8
Process Gas Combustion	0.9	-	-	0.1
Stationary IC Engines[b]	2.6	0.5	0.1	0.1
Petroleum Industry	22.6	9.7	13.9	6.6
Chemical Manufacturing	1.1	22.3	18.4	1.5
Evaporation	-	30.8	-	0.1
Primary Metals	0.1	1.1	24.3	10.1
Mineral Products	1.4	0.1	0.1	25.4
Secondary Metals	0.1	-	4.1	1.1
Wood Products	0.1	0.2	2.8	2.9
Point Source Emissions Selected for Study	86.9	66.4	65.5	80.8
Remaining Point Source Emissions	-	3.6	18.0	4.7
Total Area Source Emissions	13.1	30.0	16.5	14.5
Total Stationary Source Emissions	100.0	100.0	100.0	100.0

[a] Data extracted from Ref. 1-4.

[b] Internal combustion (IC) engines.

20 percent of all NO_x from stationary sources originated from process gas combustion. This information was supported by the large process gas combustion rates listed in Ref. 1-4. Study of the actual data stored in the NEDS (from a data tape) showed that large errors in the original data for two users of process gases accounted for nearly all of the previously reported nationwide process gas usage rates and, therefore, for nearly all of the reported NO_x emissions in this category. These errors were reported, checked, and confirmed by the NEDS personnel, and greatly reduced NO_x emissions are now as reported in Table 1-12.

The stationary internal combustion engines category, although contributing only small quantities of emissions (Ref. 1-4), was chosen because the NO_x emissions could be very large, depending on the usage rates of a large population (Ref. 1-5) of gasoline-fueled engines, each of which is too small to be classed as a point source. Although emissions from point sources in this category are small, the data are summarized, along with a discussion of this critical area source problem, in Section III.

The chemical manufacturing and petroleum refinery categories were selected because of the high emissions of NO_x, CO, and HC. These categories are reported in Sections IV and V, respectively.

Although the categories under study have been referred to as NEDS categories, the NEDS was not the only source, or even in some cases the major source, of original data. Extensive reviews of the literature were also conducted to obtain other original data as well as the rationale for projection of the data into the future. The data obtained, consisting of necessary calculations, sources, and results, are different for each of the general categories studied, and discussions of these data are contained in each of the following sections of this report. The NEDS data acquisition and evaluation techniques were generally common to all categories studied.

1.4.2 Preliminary NEDS Data Evaluation

In each study, a computer tape of all point source data stored in the NEDS for the categories of interest were requested from EPA.

Initially, the data contained on the tape were analyzed (by computer) to determine the significant Source Classification Code (SCC). The NEDS SCC is listed and described in Appendix A.2 of Ref. 1-1. This summary of emissions by the NEDS SCC was reviewed to determine those categories containing the bulk of the four emissions. In most cases it was found that a small number of SCC categories accounted for nearly all of the emissions of each type in the general category chosen for study. Therefore, the total of emissions of some types for the entire general category chosen for study was comparatively insignificant. Considering the rather large ranges of uncertainty in the emissions from other major categories, it was not considered cost-effective to study these small categories. A general measure used to rule out study of certain emissions within a general category or to rule out study of certain SCCs altogether was based on one percent of the total stationary point source emissions. If the sum of any one of the four selected air pollution emissions over the entire general category was less than one percent, emissions of that pollutant were neglected. In certain groups of SCCs, none of the four emissions exceeded one percent, and these SCCs were neglected.

Reference 1-1 lists all the SCCs represented on the NEDS data tape in each of the general categories selected for study. Each data section in this report shows those SCCs studied. The SCCs listed in the appropriate category in Ref. 1-1 but not listed in the corresponding data section of this report were neglected for the above reasons. In cases where any of the four air pollutants were negligible, the data printout indicates "negligible."

The SCCs which were considered significant for one or more of the emissions were then reviewed for data entries indicating excessive process charge rates or emissions. The most commonly used technique to check charge rates was to review the process state of the art, select a large processing plant, and execute a computer search for point sources with listed charge rates greater than this expected maximum. If such cases were discovered, all of the data for that plant and point source were printed for further review. Many cases were found, in this manner, where the listed charge rates were 100 to 1000 times that considered reasonable for a large plant (in some cases even larger than the entire national capacity). In most categories, no equivalent reliable check could be devised, however, for charge rates listed too low. After correction of the data for charge rates listed too high, the corrected total was compared with other original data from the literature.

Erroneously recorded emissions were checked by comparing emission factors calculated from the NEDS tape data on emissions and charge rates against the latest emission factors recorded in Ref. 1-2. Some errors in the listed emissions were uncovered in this manner. A more common error, however, resulted from the accepted practice of calculating the emissions from the best estimate of emission factors and the charge rate, instead of from actual measurements. Since most of the data currently stored in the NEDS was entered in the 1970 through 1972 time period, emission factors were approximately those listed in Ref. 1-3. Corrections in emission factors between the Ref. 1-3 listing and the subsequent listing in Ref. 1-2 in some cases increased or decreased the emission factors by factors of as much as 75 and 40, respectively.

1.4.3 Data Coding

The NEDS data categories are identified by an eight-digit number called the SCC. Where possible and where one or more emissions in a given SCC were large, a further detailed breakdown of the data in that SCC was effected. To facilitate handling of this more detailed data and yet maintain close correspondence with the established NEDS SCC data coding system, a modified SCC (MSCC) system was initiated for this study. A ninth digit was added to all of the eight-digit NEDS SCCs to form the MSCCs used in this study. All of the NEDS SCCs, then, appear in this study with an additional zero in the last place of a nine-digit code number. Where additional breakdown of data in a NEDS SCC was possible and desirable, the last place in the nine-digit code of this study shows a nonzero digit. For example, the NEDS SCC category 1-01-002-02 identifies raw, original data stored for the category: external combustion, boiler (1-xx-xxx-xx); electric generation (1-01-xxx-xx); bituminous coal (1-01-002-xx); fired as pulverized coal in dry-bottom boilers of capacity greater than 100 million Btu/hr (1-01-002-02). This same general category is identified in this study by the MSCC 101002020. This MSCC, in this study, however, is considered a fourth-level summary because the additional breakdowns 101002021 through 101002024 have been included to divide those data into the boiler firing types: tangential, opposed, single-wall, and vertical, respectively. These are now the data levels, and the MSCC 101002020 represents the sum of the emissions and charge rates of the four data SCCs. Where practical the process assigned to each MSCC was the same as that assigned by the NEDS to the corresponding SCC. In any case, the process corresponding to each MSCC is defined in the first table of the respective sections.

Although the data coding system used in this study closely parallels that of the NEDS system, the data actually stored and used in this study were acquired from a number of sources (including NEDS). The original data base being accumulated in the data storage and handling program at The Aerospace Corporation, then, represents a careful and judicious sum from other sources as well as NEDS.

1.5 DATA HANDLING AND STORAGE

The sheer volume of data being generated in this study immediately dictates the use of a computer system for storage and handling. After only the first year of study, 102 MSCC categories have been defined for storage of significant data. In each of the MSCCs, 40 separate bits of information must be entered into storage. In any particular MSCC, a particular storage location may contain data either in the form of a number or an indication that the particular data are negligible. Thus, a total of 4080 data entries have already been entered into the program.

The general form of the data storage and handling program is based on two major considerations:

a. The data acquired from various sources represent different points in time. Particularly because of the rapidly changing energy picture, much of those data may have changed considerably between the time of acquisition and the time of this study. Data acquired and stored in general categories at the beginning of this study will be three years older at the time of the first planned update. Users of the data need to have available an estimate of emissions in the time period of implementation of control systems (i.e., in the future) rather than at the time of planning.

b. Complete and accurate original data are difficult to acquire. As a result, little good data are available, and data from several sources are often widely discrepant. As estimates of future emissions are highly desirable, it is important to know how uncertain these projections are.

1.5.1 Data Projections

In response to the need for current and future emissions estimates as well as a set of values upon which these estimates and projections can be evaluated as to their accuracy, a data storage and handling program was developed. As in the NEDS summary system, emissions of each of the four air pollutants NO_x, CO, HC, and PART are calculated from charge rates and emission factors:

$$\text{Emissions} = \text{Emission Factor} \times \text{Charge Rate} \qquad (1\text{-}1)$$

For all four of the emissions in a single SCC, the charge rate is the same and is fundamental data in itself. For that reason, storage space is available for three values of the charge rate (with the appropriate year of the data) for each MSCC.

For NO_x, CO, and HC emissions, the appropriate emission factors are entered directly and used with the charge rates as in Eq. (1-1) to calculate emissions. As such, these emission factors directly reflect the average degree of control of emissions in all processes represented by the MSCC. Since the degree of control may change with time, either because of more effective control or more widespread application of the same degree of control, the emission factor must be projected into the future independently of the charge rates.

PART emissions, however, are normally controlled by special hardware. Since these are recognizable pieces of hardware with relatively well established PART collection efficiencies, both the collector efficiency and the degree of application of such collectors to processes represented in the MSCC can be determined. The emission factors in Eq. (1-1) for PART emissions, then, are calculated from an uncontrolled emission factor for the process, a function of the average collector efficiency, and the average degree of application of this average collector:

$$\text{PART Emission Factor} = \text{Uncontrolled Emission Factor} \times (1 - \text{Collector Efficiency}) \times \text{Fraction of Application of the Collector} \quad (1\text{-}2)$$

It is assumed that the uncontrolled PART emission factor is fundamental to the process and will not change with time. Both the average collector efficiency and the degree of application of this average collector, however, can change with time, and both must be projected independently into the future.

Thus, six time-dependent variables must be entered into the program storage in order to calculate emissions of the four air pollutants of interest: the latest charge rate, the three controlled emission factors, the PART collector efficiency, and the degree of application of the PART collector. Because of the widely varying sources of these data, they hardly ever represent the same period in time. Therefore, the original data cannot be meaningfully combined directly to calculate emissions. The data storage and handling program allows for three separate years of record for (1) the latest charge rate, (2) all three controlled emission factors and the PART control efficiency, and (3) the degree of PART control application. Whenever emissions are calculated, according to Eqs. (1-1) and (1-2), these time-dependent variables must be projected from their individual years of record to the same date.

The projection of these six time-dependent variables into the future required a time-dependent projection equation. In light of the large uncertainties in the original data and the usual uncertainties of the future, no more sophisticated equation than a straight line is justified. Thus, for each of the six time-dependent variables, a linear slope with time (a time derivative) must also be determined from appropriate rationale (e.g., control equation efficiency and degree of application) and stored in the data storage and handling program. All calculations of emissions thus start with the original data for the six time-dependent variables, use the six appropriate linear slopes to project these variables to some common time, and then calculate emissions from the projected values according to Eqs. (1-1) and (1-2). In this report, the charge rate and emission raw data base are generated by projecting all of the data to the current year. A further projection is made for five years into the future.

1.5.2 Data Uncertainties

The second major consideration in the development of the data storage and handling program relates to the uncertainties in the data. As related in Section 1.4.1, data have been found that were in error by two and three orders of magnitude. Differences between independent original sources of the same data are often as large as factors of two. The recent wide variations in charge rates with time, resulting first from the impact of environmental considerations and from the energy shortage, make projections into the future uncertain. If users of the data reported here intend to give weight to certain emissions projected for different sources, then it becomes important that the user have values of the uncertainty in those emissions.

Even an estimate of the uncertainties in the data is difficult because of the lack of data. Adequate data are not available from a sufficient number of original sources that a reasonable statistical estimate of uncertainty can be made. The use of small data sample statistics results in unrealistically large uncertainties. In most cases, only two sources (and sometimes only one source) are available.

Usually, however, certain engineering methods can be followed in estimating realistic bounds on some given data or time-dependent slope from better-known data. For example, current levels of total electrical demand and total installed electric-generating capacity are reasonably widely studied and well documented. By using engineering judgment to set various realistic upper and lower bounds on less well-documented data, such as a breakdown of electric-generating capacity into fuels, firing types, and plant sizes, an engineering estimate of a reasonable uncertainty range around the data on charge rates in large pulverized coal-fired, electric-generating boilers can be obtained. It may also be possible, from a description of a particular study or survey, to make an engineering estimate of the degree of completeness and accuracy of the results. Some cases remain where no data other than a single estimate from the literature and the corresponding NEDS data are available. In such cases, there is no alternative other than to take the data as the average of the two available estimates and the uncertainty range as the difference between the two.

Some fairly clear limits exist, or are defined here, on projections into the future. In most cases, Aerospace familiarity with the basic processes generating or controlling emissions is sufficient that lower limits on emission factors can be estimated with reasonable confidence, at least for the near future. These lower limits are stored in the data storage and handling program, and the program will not allow the NO_x, CO, or HC emission factors (minus the uncertainty) to drop below these limits. Similarly, upper limits are set on PART collector efficiencies. The degree of application of a collector cannot exceed 1.0. Because of the social pressure in all areas to reduce air pollution, the assumption was made in this program that the maximum value of a projected emission factor (the projected nominal value plus the projected uncertainty) cannot exceed the current maximum value (i.e., no increase in emission factors). Of course, no charge rates or emissions, including uncertainties, are allowed to be negative. Limits such as those discussed in this paragraph can result in unsymmetrical uncertainties in projected data levels. For example, the 1975 NO_x emission for MSCC 101002000 is

$$4.897 + \frac{1.046}{-0.348} \times 10^6 \frac{\text{Tons}}{\text{Year}}.$$

The above discussion outlines the methods used and problems encountered in generating engineering estimates of uncertainty in the data shown in this report. The fact that it is so difficult to generate these estimates underlines the need to provide the user with the documentation of the uncertainty of these data. These uncertainties are not statistical quantities. It is necessary, however, to combine the uncertainty estimates of charge rate, emission factor, collector efficiency, control equipment application data, and the derivatives of these with time slopes, to establish the uncertainties of emission data projected into the future. In the data storage and handling program, these are treated as statistical quantities (standard deviation). The resulting uncertainties in the projected emissions are considered engineering estimates.

1.6 REFERENCES

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1-2. Compilation of Air Pollutant Emission Factors, 2nd ed., AP-42, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (April 1973).

1-3. Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (February 1972).

1-4. Nationwide Emissions Summary, National Emissions Data System, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (January 10, 1975).

1-5. W. U. Roessler, et al., Assessment of the Applicability of Automotive Emission Control Technology to Stationary Engines, EPA-65012-74-051, The Aerospace Corporation, El Segundo, California (July 1974).

SECTION II

EXTERNAL COMBUSTION IN BOILERS

2.1 INTRODUCTION

The external combustion (boiler) category of stationary emission sources includes all of the fuels burned in stationary boilers for the purpose of generating steam for electric generation and various other industrial purposes. According to the National Emissions Data System (NEDS) nationwide emissions report of January 10, 1975 (Ref. 2-1), this category, at least in the 1970 to 1973 time period, represented the largest single stationary source of both oxides of nitrogen (NO_x) and particulate (PART) emissions. NO_x emissions of over 8 million tons per year represented about 59 percent of NO_x emissions from all stationary sources and about 36 percent of NO_x emissions from all sources inventoried by the NEDS. PART emissions of over 5 million tons per year represented about 33 percent of PART emissions from all stationary sources and 31 percent of this air pollutant emitted from all sources. Hydrocarbon (HC) and carbon monoxide (CO) emissions from sources in this category represented less than two percent, each, of those from all stationary sources. The external combustion (boiler) category was the first to be studied in this continuing inventory because of the large NO_x and PART emissions.

A wide range of fuels is burned in external combustion boilers, including the following:

a. Coal: anthracite, bituminous, and lignite
b. Oil: residual and distillate

c. Gas: natural and processed
d. Wood
e. Bagasse
f. Coke
g. Liquified petroleum gas
h. Other minor fuels

Of the NO_x and PART generated from the external combustion of these fuels, for electric generation and various industrial purposes, in single sources emitting more than 100 tons per year of these air pollutants (point sources), the combustion of bituminous coal is by far the largest fuel source. More than 58 and 88 percent of the NO_x and PART, respectively, from the external combustion, boiler category result from the combustion of bituminous coal. Other fuel combustion which contributes significantly to the emission of NO_x and PART includes that of natural gas and oil.

At the time that the fuels to be studied in this portion of the inventory were selected, the then existing NEDS emission summary (Ref. 2-2, dated December 19, 1973) indicated that process gas combustion in industrial boilers and heaters was the source of 2.6 million tons per year of NO_x and resulted from the annual combustion of more than 2×10^{13} cu ft/year of such gaseous fuels. This fuel category, therefore, was included in those to be studied. During the study, it was found that large errors in the fuel usage (annual charge rate) data submitted by two companies accounted for over 90 percent of the listed annual process gas combustion and more than 80 percent of the listed NO_x emissions from process gas combustion. These errors have subsequently been corrected in the NEDS data bank. The NEDS emissions inventory of January 10, 1975 (Ref. 2-1) indicates only about 11,000 tons per year of NO_x from combustion of process gas. Since this fuel category was studied, however, it is included in the projections in this section even though the emissions are small or negligible. No significant effort was made to estimate future changes in process gas usage rates or emission factors.

The fuels selected for study in this inventory were bituminous coal, residual and distillate oil, natural gas, and process gas. These five fuels account for 96 and 92 percent, respectively, of the NO_x and PART generated from external combustion, electric generation, and industrial point sources. All other fuels except lignite and wood represent sources of less than one percent of these pollutants. Lignite represents the source of just over one percent of the pollutants from this category and was neglected. Wood combustion represents the source of nearly two percent and more than four percent of the NO_x and PART, respectively, from this category. The more general category of wood products, including wood combustion, also represents a significant source of CO emissions. As a result, study of the more general categories related to wood use was not neglected but was deferred to a later date.

2.2 SUMMARY

The NEDS Source Classification Code (SCC) for external combustion (boiler) point source categories was modified according to the fuels utilized in utility and industrial boilers and inventoried by this study. Table 2-1, therefore, identifies the source categories studied according to the Aerospace-developed Modified Source Classification Code (MSCC) and presents the total annual charge rate projected (TACRP) unit for each

A summary of the 1975 and 1980 emissions and charge rates for the external combustion (boiler) categories was compiled and is given in Tables 2-2-a and 2-3-a, respectively, and in Tables 2-4-a and 2-5-a for 1976 and 1981. The uncertainties in the emission and charge rate data for 1975 and 1980 are given in Tables 2-2-b and 2-3-b, respectively, and in Tables 2-4-b and 2-5-b for 1976 and 1981.

2.3 APPROACH

Study of fuel usage, emission factors, and projection data in the external combustion (boiler) category was initiated in this study solely from the available literature. In many areas, however, the available data did not provide a sufficient breakdown of firing types nor sufficient multiple sources to evaluate data accuracy (or uncertainty). As a result, a computer

(Continued on page 2-40)

Table 2-1. Definition of External Combustion (Boiler) Processes

MSCC	Source Category	TACRP Unit
101000000	Utility Boilers	
101002000	Bituminous coal	Tons/yr
101002010	>100 MMBtu/hr pulverized wet	Tons/yr
101002020	>100 MMBtu/hr pulverized dry	Tons/yr
101002021	Tangential firing	Tons/yr
101002022	Opposed firing	Tons/yr
101002023	Single-wall firing	Tons/yr
101002024	Vertical firing	Tons/yr
101002030	>100 MMBtu/hr cyclone	Tons/yr
101002040	>100 MMBtu/hr spreader stoker	Tons/yr
101002050	>100 MMBtu/hr overfeed stoker	Tons/yr
101002060	10 to 100 MMBtu/hr pulverized wet	Tons/yr
101002070	10 to 100 MMBtu/hr pulverized dry	Tons/yr
101002080	10 to 100 MMBtu/hr overfeed stoker	Tons/yr
101002090	10 to 100 MMBtu/hr underfeed stoker	Tons/yr
101002100	<10 MMBtu/hr overfeed stoker	Tons/yr
101002110	<10 MMBtu/hr underfeed stoker	Tons/yr
101002120	<10 MMBtu/hr pulverized dry	Tons/yr
101004000	Residual oil	1000 gal/yr
101004010	>100 MMBtu/hr general	1000 gal/yr
101004011	Tangential firing	1000 gal/yr
101004012	Opposed firing	1000 gal/yr

Table 2-1. Definition of External Combustion (Boiler) Processes (Continued)

MSCC	Source Category	TACRP Unit
101004013	Single-wall firing	1000 gal/yr
101004014	Vertical firing	1000 gal/yr
101004020	10 to 100 MMBtu/hr general[a]	1000 gal/yr
101004030	<10 MMBtu/hr general	1000 gal/yr
101005000	Distillate oil	1000 gal/yr
101005010	>100 MMBtu/hr general	1000 gal/yr
101005020	10 to 100 MMBtu/hr general	1000 gal/yr
101005030	<10 MMBtu/hr general	1000 gal/yr
101006000	Natural gas	Million cu ft/yr
101006010	>100 MMBtu/hr general	Million cu ft/yr
101006011	Tangential firing	Million cu ft/yr
101006012	Opposed firing	Million cu ft/yr
101006013	Single wall firing	Million cu ft/yr
101006014	Vertical firing	Million cu ft/yr
101006020	10 to 100 MMBtu/hr general	Million cu ft/yr
101006030	<10 MMBtu/hr general	Million cu ft/yr
101007000	Process gas	Million cu ft/yr
101007010	>100 MMBtu/hr general	Million cu ft/yr
101007020	10 to 100 MMBtu/hr general	Million cu ft/yr
101007030	<10 MMBtu/hr general	Million cu ft/yr

Table 2-1. Definition of External Combustion (Boiler) Processes (Continued)

MSCC	Source Category	TACRP Unit
102000000	Industrial Boilers	
102002000	Bituminous coal	Tons/yr
102002010	>100 MMBtu/hr pulverized wet	Tons/yr
102002020	>100 MMBtu/hr pulverized dry	Tons/yr
102002030	>100 MMBtu/hr cyclone	Tons/yr
102002040	>100 MMBtu/hr spreader stoker	Tons/yr
102002050	10 to 100 MMBtu/hr overfeed stoker	Tons/yr
102002060	10 to 100 MMBtu/hr underfeed stoker	Tons/yr
102002070	10 to 100 MMBtu/hr wet pulverized	Tons/yr
102002080	10 to 100 MMBtu/hr dry pulverized	Tons/yr
102002090	10 to 100 MMBtu/hr spreader stoker	Tons/yr
102002100	<10 MMBtu/hr overfeed stoker	Tons/yr
102002110	<10 MMBtu/hr underfeed stoker	Tons/yr
102002120	<10 MMBtu/hr dry pulverized	Tons/yr
102002130	<10 MMBtu/hr spreader stoker	Tons/yr
102004000	Residual-oil-fired	1000 gal/yr
102004010	>100 MMBtu/hr residual-oil-fired	1000 gal/yr
102004020	1 to 10 MMBtu/hr residual-oil-fired	1000 gal/yr
102004030	<10 MMBtu/hr residual-oil-fired	1000 gal/yr

Table 2-1. Definition of External Combustion (Boiler) Processes (Continued)

MSCC	Source Category	TACRP Unit
102005000	Distillate-oil-fired	1000 gal/yr
102005010	>100 MMBtu/hr distillate-oil-fired	1000 gal/yr
102005020	10 to 100 MMBtu/hr distillate-oil-fired	1000 gal/yr
102005030	<10 MMBtu/hr distillate-oil-fired	1000 gal/yr
102006000	Natural-gas-fired	Million cu ft/yr
102006010	>100 MMBtu/hr natural-gas-fired	Million cu ft/yr
102006020	10 to 100 MMBtu/hr natural-gas-fired	Million cu ft/yr
102006030	<10 MMBtu/hr natural-gas-fired	Million cu ft/yr
102007000	Process gas-fired	Million cu ft/yr
102007010	>100 MMBtu/hr process gas-fired	Million cu ft/yr
102007020	10 to 100 MMBtu/hr process-gas-fired	Million cu ft/yr
102007030	<10 MMBtu/hr process-gas-fired	Million cu ft/yr

[a] Million British thermal units (MMBtu).

Table 2-2-a. 1975 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101002000	389250000.	4.897	.070	.199	4.205
101002010	45830000.	.573	.007	.023	.826
101002020	277100000.	2.716	.050	.139	2.940
101002021	146060000.	.974	.022	.073	1.550
101002022	58780000.	.781	.009	.029	.624
101002023	57900000.	.769	.009	.029	.614
101002024	14360000.	.191	.011	.007	.152
101002030	54080000.	1.509	.008	.027	.210
101002040	4200000.	.031	.002	.004	.088
101002050	1810000.	.013	.001	.002	.026
101002060	190000.	.002	.000	.000	.007
101002070	1567200.	.015	.000	.001	.023
101002080	440000.	.003	.000	.000	.006
101002090	2350000.	.017	.001	.002	.023
101002100	30000.	.000	.000	.000	.000
101002110	0.	0.000	0.000	0.000	0.000
101002120	1655800.	.016	.000	.001	.055
101004000	18210000.	.667	.018	.027	.073
101004010	17960000.	.658	.018	.027	.072
101004011	7184000.	.160	.007	.011	.029
101004012	5200000.	.232	.005	.008	.021
101004013	5200000.	.232	.005	.008	.021
101004014	376000.	.034	.000	.001	.002
101004020	240000.	.009	.000	.000	.001
101004030	10000.	.000	.000	.000	.000
101005000	0.	0.000	0.000	0.000	0.000
101005010	0.	0.000	0.000	0.000	0.000
101005020	0.	0.000	0.000	0.000	0.000
101005030	0.	0.000	0.000	0.000	0.000

Table 2-2-a. 1975 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 2

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101006000	2993400.	.673	.001	.025	.022
101006010	2936000.	.660	.001	.025	.022
101006011	776000.	.097	.000	.007	.006
101006012	1208000.	.303	.001	.010	.009
101006013	864000.	.217	.000	.007	.006
101006014	88000.	.044	.000	.001	.001
101006020	53000.	.012	.000	.000	.000
101006030	4400.	.001	.000	.000	.000
101007000	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007010	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007020	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007030	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102002000	57234000.	.592	.023	.051	1.055
102002010	5340000.	.067	.001	.003	.085
102002020	5880000.	.058	.001	.003	.123
102002030	6100000.	.170	.001	.003	.031
102002040	23120000.	.172	.012	.023	.491
102002050	1030000.	.008	.001	.001	.025
102002060	4370000.	.032	.002	.004	.077
102002070	260000.	.003	.000	.000	.013
102002080	620000.	.006	.009	.000	.015
102002090	9784000.	.073	.005	.010	.189
102002100	270000.	.001	.000	.001	.002
102002110	120000.	.000	.000	.001	.002
102002120	0.	0.000	0.000	0.000	0.000
102002130	340000.	.002	.001	.002	.003
102004000	12100000.	.290	.018	.024	.139
102004010	7650000.	.184	.011	.015	.088
102004020	3920000.	.094	.006	.008	.045

Table 2-2-a. 1975 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 3

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
102004030	530000.	.013	.001	.001	.006
102005000	7060000.	.169	.011	.014	.053
102005010	5186000.	.124	.008	.010	.039
102005020	1684000.	.040	.003	.003	.013
102005030	190000.	.005	.000	.000	.001
102006000	3520000.	.303	.005	.030	.032
102006010	2060000.	.177	.003	.018	.019
102006020	924000.	.079	.001	.008	.008
102006030	536000.	.046	.001	.005	.005
102007000	1749300.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007010	1257000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007020	464000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007030	28260.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Table 2-2-b. 1975 EXTERNAL COMBUSTION UNCERTAINTIES

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                   EXTERNAL COMBUSTION, BOILER CATEGORY                        PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE= MAR 22,1977
 MODIFIED            TACRP                       EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC            (SCC UNITS)              NOX             HC              CO             PART
101002000     +    11708000.          +  .348         +  .097         +  .069         +  .431
              -    11708000.          -  .348         -  .014         -  .046         -  .431

101002010     +     4651900.          +  .099         +  .005         +  .017         +  .271
              -     4651900.          -  .099         -  .004         -  .012         -  .271
101002020     +     9643300.          +  .253         +  .097         +  .063         +  .325
              -     9643300.          -  .253         -  .013         -  .042         -  .325

101002021     +     8365000.          +  .166         +  .017         +  .055         +  .282
              -     8365000.          -  .166         -  .011         -  .037         -  .282
101002022     +     3360300.          +  .134         +  .068         +  .022         +  .113
              -     3360300.          -  .134         -  .004         -  .015         -  .113
101002023     +     3324500.          +  .132         +  .067         +  .022         +  .112
              -     3324500.          -  .132         -  .004         -  .015         -  .112
101002024     +      822190.          +  .033         +  .008         +  .005         +  .028
              -      822190.          -  .033         -  .001         -  .004         -  .028

101002030     +     4686100.          +  .218         +  .006         +  .020         +  .063
              -     4686100.          -  .218         -  .004         -  .014         -  .063
101002040     +      632460.          +  .006         +  .002         +  .003         +  .027
              -      632460.          -  .006         -  .002         -  .002         -  .027
101002050     +      172050.          +  .002         +  .001         +  .001         +  .011
              -      172050.          -  .002         -  .001         -  .001         -  .011
101002060     +       29732.          +  .001         +  .000         +  .000         +  .004
              -       29732.          -  .001         -  .000         -  .000         -  .004
101002070     +       78102.          +  .003         +  .000         +  .001         +  .003
              -       78102.          -  .003         -  .000         -  .000         -  .003
101002080     +       63245.          +  .001         +  .000         +  .000         +  .002
              -       63245.          -  .001         -  .000         -  .000         -  .002
101002090     +      156200.          +  .002         +  .001         +  .002         +  .009
              -      156200.          -  .002         -  .001         -  .001         -  .009
101002100     +           0.          +  .000         +  .000         +  .000         +  .000
              -           0.          -  .000         -  .000         -  .000         -  .000
101002110     +           0.          + 0.000         + 0.000         + 0.000         + 0.000
              -           0.          - 0.000         - 0.000         - 0.000         - 0.000
101002120     +      106300.          +  .003         +  .000         +  .001         +  .042
              -      106300.          -  .003         -  .000         -  .000         -  .042
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Table 2-2-b. 1975 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                    EXTERNAL COMBUSTION, BOILER CATEGORY                        PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE= MAR 22,1977
MODIFIED            TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC            (SCC UNITS)          NOX            HC              CO            PART

101004000     +     2111300.       +  .096       +  .008       +  .012       +  .008
              -     2111300.       -  .096       -  .006       -  .008       -  .008

101004010     +     2111300.       +  .096       +  .008       +  .012       +  .008
              -     2111300.       -  .096       -  .006       -  .008       -  .008

101004011     +     1464800.       +  .041       +  .006       +  .009       +  .006
              -     1464800.       -  .041       -  .004       -  .006       -  .006
101004012     +     1080000.       +  .060       +  .004       +  .008       +  .004
              -     1080000.       -  .060       -  .003       -  .004       -  .004
101004013     +     1068300.       +  .059       +  .004       +  .006       +  .004
              -     1068300.       -  .059       -  .003       -  .004       -  .004
101004014     +       63245.       +  .008       +  .000       +  .000       +  .000
              -       63245.       -  .008       -  .000       -  .000       -  .000

101004020     +           0.       +  .001       +  .000       +  .000       + 0.000
              -           0.       -  .001       -  .000       -  .000       - 0.000
101004030     +           0.       +  .000       +  .000       +  .000       + 0.000
              -           0.       -  .000       -  .000       -  .000       - 0.000

101005000     +           0.       + 0.000       + 0.000       + 0.000       + 0.000
              -           0.       - 0.000       - 0.000       - 0.000       - 0.000

101005010     +           0.       + 0.000       + 0.000       + 0.000       + 0.000
              -           0.       - 0.000       - 0.000       - 0.000       - 0.000
101005020     +           0.       + 0.000       + 0.000       + 0.000       + 0.000
              -           0.       - 0.000       - 0.000       - 0.000       - 0.000
101005030     +           0.       + 0.000       + 0.000       + 0.000       + 0.000
              -           0.       - 0.000       - 0.000       - 0.000       - 0.000

101006000     +      590090.       +  .139       +  .001       +  .012       +  .004
              -      590090.       -  .139       -  .001       -  .009       -  .004

101006010     +      589870.       +  .139       +  .001       +  .012       +  .004
              -      589870.       -  .139       -  .001       -  .009       -  .004

101006011     +      265350.       +  .036       +  .000       +  .005       +  .002
              -      265350.       -  .036       -  .000       -  .004       -  .002
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Table 2-2-b. 1975 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                    EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE  3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE= MAR 22,1977
 MODIFIED         TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX             HC              CO             PART
101006012  +     427930.       +  .109       +  .001        +  .009        +  .003
           -     427930.       -  .109       -  .000        -  .006        -  .003
101006013  +     305750.       +  .078       +  .000        +  .006        +  .002
           -     305750.       -  .078       -  .000        -  .004        -  .002
101006014  +      30594.       +  .016       +  .000        +  .001        +  .000
           -      30594.       -  .016       -  .000        -  .000        -  .000

101006020  +      16000.       +  .005       +  .000        +  .000        +  .000
           -      16000.       -  .005       -  .000        -  .000        -  .000
101006030  +       1400.       +  .000       +  .000        +  .000        +  .000
           -       1400.       -  .000       -  .000        -  .000        -  .000

101007000  +      15220.       +  .000       NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
           -      15220.       -  .000       NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE

101007010  +      15220.       +  .000       NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
           -      15220.       -  .000       NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
101007020       NEGLIGIBLE       NEGLIGIBLE  NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
                NEGLIGIBLE       NEGLIGIBLE  NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
101007030       NEGLIGIBLE       NEGLIGIBLE  NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
                NEGLIGIBLE       NEGLIGIBLE  NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE

102002000  +    6431600.       +  .075       +  .010        +  .020        +  .190
           -    6431600.       -  .075       -  .010        -  .014        -  .190

102002010  +     796490.       +  .014       +  .001        +  .002        +  .020
           -     796490.       -  .014       -  .000        -  .001        -  .020
102002020  +    4091400.       +  .041       +  .001        +  .003        +  .089
           -    4091400.       -  .041       -  .001        -  .003        -  .089
102002030  +    1486600.       +  .046       +  .001        +  .002        +  .011
           -    1486600.       -  .046       -  .001        -  .002        -  .011
102002040  +    4049500.       +  .035       +  .009        +  .018        +  .141
           -    4049500.       -  .035       -  .009        -  .012        -  .141
102002050  +     106300.       +  .001       +  .000        +  .001        +  .005
           -     106300.       -  .001       -  .000        -  .001        -  .005
102002060  +     884080.       +  .007       +  .002        +  .003        +  .022
           -     884080.       -  .007       -  .002        -  .002        -  .022
```

Table 2-2-b. 1975 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                         EXTERNAL COMBUSTION, BOILER CATEGORY                  PAGE  4
 TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE= MAR 22,1977
  MODIFIED            TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC            (SCC UNITS)          NOX             HC              CO              PART
 102002070     +       34409.     +  .001       +  .000       +  .006       +  .004
               -       34409.     -  .001       -  .000       -  .006       -  .004
 102002080     +      417610.     +  .004       +  .000       +  .000       +  .010
               -      417610.     -  .004       -  .000       -  .000       -  .010
 102002090     +     2099900.     +  .017       +  .004       +  .005       +  .005
               -     2099900.     -  .017       -  .004       -  .005       -  .005
 102002100     +       34409.     +  .000       +  .000       +  .001       +  .001
               -       34409.     -  .000       -  .000       -  .001       -  .001
 102002110     +       12000.     +  .000       +  .000       +  .000       +  .001
               -       12000.     -  .000       -  .000       -  .000       -  .001
 102002120     +           0.     +  0.000      +  0.000      +  0.000      +  0.000
               -           0.     -  0.000      -  0.000      -  0.000      -  0.000
 102002130     +       59464.     +  .001       +  .000       +  .001       +  .002
               -       59464.     -  .001       -  .000       -  .001       -  .002

 102004000     +     1140100.     +  .093       +  .010       +  .012       +  .013
               -     1140100.     -  .093       -  .007       -  .009       -  .013

 102004010     +     1062800.     +  .083       +  .009       +  .011       +  .012
               -     1062800.     -  .083       -  .006       -  .008       -  .012
 102004020     +      409140.     +  .042       +  .005       +  .006       +  .005
               -      409140.     -  .042       -  .003       -  .004       -  .005
 102004030     +       53073.     +  .006       +  .001       +  .001       +  .001
               -       53073.     -  .006       -  .000       -  .001       -  .001

 102005000     +      838110.     +  .060       +  .006       +  .008       +  .006
               -      838110.     -  .060       -  .004       -  .006       -  .006

 102005010     +      807220.     +  .057       +  .006       +  .007       +  .006
               -      807220.     -  .057       -  .004       -  .003       -  [illegible]
 102005020     +      223730.     +  .018       +  .002       +  .002       +  .002
               -      223730.     -  .018       -  .001       -  .002       -  .002
 102005030     +       27724.     +  .002       +  .000       +  .000       +  .000
               -       27724.     -  .002       -  .000       -  .000       -  .000

 102006000     +      902520.     +  .089       +  .003       +  .017       +  [illegible]
               -      902520.     -  .089       -  .002       -  .012       -  [illegible]
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Table 2-2-b. 1975 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 5

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		NOX		HC		CO		PART
			EMISSIONS (MILLIONS OF TONS / YEAR)							
102006010	+	828010.	+	.077	+	.003	+	.015	+	.007
	-	828010.	-	.081	-	.002	-	.011	-	.007
102006020	+	310540.	+	.030	+	.001	+	.006	+	.003
	-	310540.	-	.032	-	.001	-	.005	-	.003
102006030	+	100280.	+	.017	+	.001	+	.004	+	.002
	-	100280.	-	.018	-	.000	-	.003	-	.002
102007000	+	142990.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	142990.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
102007010	+	125700.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	125700.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
102007020	+	60100.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	60100.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
102007030	+	2800.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	2800.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE

Table 2-3-a. 1980 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101002000	459910000.	4.688	.083	.234	4.001
101002010	45830000.	.458	.007	.023	.660
101002020	338100000.	2.716	.061	.169	2.979
101002021	178210000.	.975	.027	.089	1.570
101002022	71730000.	.781	.011	.036	.632
101002023	70650000.	.769	.011	.035	.622
101002024	17510000.	.191	.013	.009	.154
101002030	63030000.	1.428	.009	.03[illegible]	.188
101002040	4200000.	.025	.002	.004	.066
101002050	1810000.	.011	.001	.002	.020
101002060	190000.	.002	.000	.000	.005
101002070	1910200.	.015	.000	.001	.024
101002080	440000.	.003	.000	.000	.005
101002090	2350000.	.016	.001	.002	.017
101002100	30000.	.000	.000	.000	.000
101002110	0.	0.000	0.000	0.000	0.000
101002120	2020300.	.016	.002	.001	.037
101004000	26860000.	.245	.027	.040	.107
101004010	26610000.	.243	.027	.040	.106
101004011	10644000.	.059	.011	.016	.043
101004012	7700000.	.085	.008	.012	.031
101004013	7700000.	.085	.008	.012	.031
101004014	566000.	.013	.001	.001	.002
101004020	240000.	.002	.000	.000	.001
101004030	10000.	.000	.000	.000	.000
101005000	0.	0.000	0.000	0.000	0.000
101005010	0.	0.000	0.000	0.000	0.000
101005020	0.	0.000	0.000	0.000	0.000
101005030	0.	0.000	0.000	0.000	0.000

Table 2-3-a. 1980 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 2

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)			
		NOX	HC	CO	PART
101006000	1986900.	.124	.001	.017	.015
101006010	1951000.	.122	.001	.017	.015
101006011	516000.	.018	.000	.004	.004
101006012	803000.	.056	.000	.007	.006
101006013	574000.	.040	.000	.005	.004
101006014	58000.	.008	.000	.000	.000
101006020	33000.	.002	.000	.000	.000
101006030	2900.	.000	.000	.000	.000
101007000	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007010	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007020	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007030	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102002000	93319000.	.793	.037	.082	1.287
102002010	8190000.	.082	.001	.004	.102
102002020	11330000.	.091	.002	.006	.192
102002030	10600000.	.240	.002	.005	.040
102002040	40220000.	.242	.020	.040	.638
102002050	1780000.	.011	.001	.002	.031
102002060	7620000.	.046	.004	.008	.092
102002070	410000.	.004	.000	.000	.014
102002080	1170000.	.009	.000	.001	.022
102002090	10769000.	.065	.005	.011	.149
102002100	470000.	.002	.001	.002	.003
102002110	170000.	.000	.000	.001	.002
102002120	0.	0.000	0.000	0.000	0.000
102002130	590000.	.003	.001	.003	.005
102004000	15350000.	.138	.023	.031	.177
102004010	9700000.	.087	.015	.019	.112
102004020	4970000.	.045	.007	.010	.057

Table 2-3-a. 1980 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 3

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
102004030	680000.	.006	.001	.001	.008
102005000	8960000.	.081	.013	.018	.067
102005010	6586000.	.059	.010	.013	.049
102005020	2134000.	.019	.003	.004	.016
102005030	240000.	.002	.000	.000	.002
102006000	2320000.	.147	.003	.0[illegible]0	.021
102006010	1360000.	.086	.002	.012	.012
102006020	609000.	.039	.001	.005	.005
102006030	351000.	.022	.001	.003	.003
102007000	1749300.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007010	1257000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007020	4[illegible]4000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007030	28260.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Table 2-3-b. 1980 EXTERNAL COMBUSTION UNCERTAINTIES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)	NOX		HC		CO		PART
101002000	+	30577000.	+	.771	+	.118	+	.084	+	.812
	-	30577000.	-	.771	-	.017	-	.057	-	.810
101002010	+	14835000.	+	.218	+	.006	+	.019	+	.321
	-	14835000.	-	.218	-	.004	-	.014	-	.321
101002020	+	23282000.	+	.486	+	.118	+	.078	+	.739
	-	23282000.	-	.486	-	.016	-	.053	-	.737
101002021	+	20194000.	+	.321	+	.021	+	.068	+	.641
	-	20194000.	-	.321	-	.014	-	.046	-	.640
101002022	+	8108100.	+	.256	+	.082	+	.027	+	.258
	-	8108100.	-	.256	-	.006	-	.018	-	.257
101002023	+	8032200.	+	.253	+	.081	+	.027	+	.254
	-	8032200.	-	.253	-	.005	-	.018	-	.254
101002024	+	1989100.	+	.063	+	.010	+	.007	+	.063
	-	1989100.	-	.063	-	.001	-	.004	-	.063
101002030	+	12952000.	+	.556	+	.008	+	.025	+	.078
	-	12952000.	-	.556	-	.005	-	.017	-	.078
101002040	+	2109500.	+	.015	+	.002	+	.004	+	.042
	-	2109500.	-	.015	-	.002	-	.003	-	.042
101002050	+	500100.	+	.005	+	.001	+	.001	+	.011
	-	500100.	-	.005	-	.001	-	.001	-	.011
101002060	+	98508.	+	.001	+	.000	+	.000	+	.004
	-	98508.	-	.001	-	.000	-	.000	-	.004
101002070	+	215870.	+	.005	+	.000	+	.001	+	.006
	-	215870.	-	.005	-	.000	-	.000	-	.006
101002080	+	210950.	+	.002	+	.000	+	.000	+	.003
	-	210950.	-	.002	-	.000	-	.000	-	.003
101002090	+	431740.	+	.005	+	.001	+	.002	+	.008
	-	431740.	-	.005	-	.001	-	.001	-	.010
101002100	+	0.	+	.000	+	.000	+	.000	+	.000
	-	0.	-	.000	-	.000	-	.000	-	.000
101002110	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101002120	+	288620.	+	.006	+	.000	+	.001	+	.035
	-	288620.	-	.006	-	.000	-	.001	-	.037

Table 2-3-b. 1980 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		NOX		HC		CO		PART
				EMISSIONS (MILLIONS OF TONS / YEAR)						
101004000	+	4618700.	+	.155	+	.012	+	.019	+	.018
	-	4618700.	-	.094	-	.009	-	.013	-	.018
101004010	+	4618700.	+	.155	+	.012	+	.019	+	.018
	-	4618700.	-	.094	-	.009	-	.013	-	.018
101004011	+	3175500.	+	.068	+	.009	+	.013	+	.013
	-	3175500.	-	.027	-	.006	-	.009	-	.013
101004012	+	2403000.	+	.098	+	.006	+	.010	+	.010
	-	2403000.	-	.063	-	.005	-	.007	-	.010
101004013	+	2337900.	+	.098	+	.006	+	.010	+	.009
	-	2337900.	-	.063	-	.005	-	.007	-	.009
101004014	+	92195.	+	.014	+	.000	+	.001	+	.000
	-	92195.	-	.011	-	.000	-	.000	-	.000
101004020	+	0.	+	.002	+	.000	+	.000	+	0.000
	-	0.	-	.001	-	.000	-	.000	-	0.000
101004030	+	0.	+	.000	+	.000	+	.000	+	0.000
	-	0.	-	.000	-	.000	-	.000	-	0.000
101005000	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005010	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005020	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005030	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101006000	+	2029500.	+	.136	+	.001	+	.019	+	[illegible]
	-	1115800.	-	.071	-	.001	-	.009	-	.008
101006010	+	2028700.	+	.136	+	.001	+	.019	+	.015
	-	1115300.	-	.071	-	.001	-	.009	-	.008
101006011	+	911540.	+	.033	+	.000	+	.008	+	.007
	-	516000.	-	.018	-	.000	-	.004	-	.004

Table 2-3-b. 1980 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                         EXTERNAL COMBUSTION, BOILER CATEGORY                         PAGE   3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980        RUN DATE= MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED          TACRP
   SCC         (SCC UNITS)         NOX            HC             CD            PART

101006012  +     1472300.       +  .106      +  .001      +  .014      +  .011
           -      803000.       -  .056      -  .000      -  .007      -  .006
101006013  +     1051700.       +  .076      +  .001      +  .010      +  .008
           -      574000.       -  .040      -  .000      -  .005      -  .006
101006014  +      105170.       +  .015      +  .000      +  .001      +  .001
           -       58000.       -  .008      -  .000      -  .000      -  .000

101006020  +       56000.       +  .004      +  .000      +  .001      +  .000
           -       33000.       -  .002      -  .000      -  .000      -  .000
101006030  +        4900.       +  .000      +  .000      +  .000      +  .000
           -        2900.       -  .000      -  .000      -  .000      -  .000

101007000  +       15220.       +  .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
           -       15220.       -  .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE

101007010  +       15220.       +  .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
           -       15220.       -  .000      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
101007020       NEGLIGIBLE      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
                NEGLIGIBLE      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
101007030       NEGLIGIBLE      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE
                NEGLIGIBLE      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE

102002000  +    12611000.       +  .171      +  .017      +  .034      +  .302
           -    12611000.       -  .171      -  .017      -  .024      -  .302

102002010  +     2226900.       +  .036      +  .001      +  .003      +  .039
           -     2226900.       -  .036      -  .001      -  .002      -  .039
102002020  +     5006000.       +  .049      +  .002      +  .005      +  .104
           -     5006000.       -  .049      -  .001      -  .004      -  .104
102002030  +     3977800.       +  .120      +  .001      +  .004      +  .021
           -     3977800.       -  .120      -  .001      -  .003      -  .021
102002040  +     9981500.       +  .100      +  .016      +  .032      +  .260
           -     9981500.       -  .100      -  .016      -  .022      -  .260
102002050  +      288620.       +  .004      +  .001      +  .001      +  .011
           -      288620.       -  .004      -  .001      -  .001      -  .012
102002060  +     2015500.       +  .019      +  .003      +  .006      +  .041
           -     2015500.       -  .019      -  .003      -  .004      -  .043
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Table 2-3-b. 1980 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                    EXTERNAL CCMBUSTION, BOILER CATEGORY                           PAGE  4
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980               RUN DATE= MAR 22,1977
 MODIFIED           TACRP            EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)       NOX             HC              CO             PART
 102002070    +      100020.    +  .002       +  .000       +  .00         +  .007
              -      100020.    -  .002       -  .000       -  .00(        -  .007
 102002080    +      580000.    +  .005       +  .000       +  .00         +  .012
              -      580000.    -  .005       -  .000       -  .00J        -  .013
 102002090    +     3002900.    +  .028       +  .004       +  .009        +  .092
              -     3002900.    -  .028       -  .004       -  .006        -  .093
 102002100    +      100020.    +  .001       +  .000       +  .001        +  .002
              -      100020.    -  .001       -  .000       -  .001        -  .002
 102002110    +       42000.    +  .000       +  .000       +  .000        +  .001
              -       42000.    -  .000       -  .000       -  .000        -  .001
 102002120    +           0.    + 0.000       + 0.000       + 0.000        + 0.000
              -           0.    - 0.000       - 0.000       - 0.(0         - 0.000
 102002130    +      197020.    +  .003       +  .001       +  .(02        +  .004
              -      197020.    -  .002       -  .001       -  .002        -  .003

 102004000    +     1686600.    +  .148       +  .013       +  .016        +  .019
              -     1686600.    -  .060       -  .009       -  .011        -  .019

 102004010    +     1608600.    +  .132       +  .011       +  .014        +  .018
              -     1608600.    -  .055       -  .008       -  .010        -  .018
 102004020    +      500600.    +  .067       +  .006       +  .007        +  .006
              -      500600.    -  .027       -  .004       -  .005        -  .006
 102004030    +       79832.    +  .009       +  .001       +  .001        +  .001
              -       79832.    -  .004       -  .001       -  .001        -  .001

 102005000    +     2072900.    +  .096       +  .009       +  .011        +  .016
              -     2072900.    -  .041       -  .006       -  .008        -  .016

 102005010    +     1983000.    +  .091       +  .008       +  .010        +  .015
              -     1983000.    -  .039       -  .006       -  .008        -  .015
 102005020    +      600050.    +  .029       +  .003       +  .003        +  .005
              -      600050.    -  .013       -  .002       -  .002        -  .(
 102005030    +       70113.    +  .003       +  .000       +  .000        +  .001
              -       70113.    -  .001       -  .000       -  .000        -  .001

 102006000    +     2648100.    +  .177       +  .004       +  .025        +  .024
              -     1530900.    -  .097       -  .002       -  .013        -  .014
```

Table 2-3-b. 1980 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                    EXTERNAL COMBUSTION, BOILER CATEGORY                 PAGE  5
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980        RUN DATE= MAR 22,1977
 MODIFIED           TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)          NOX           HC           CO          PART

102006010   +     2363500.       +  .158     +  .004     +  .022     +  .021
            -     1360000.       -  .086     -  .002     -  .312     -  .012
102006020   +     1033800.       +  .069     +  .002     +  .010     +  .009
            -      609000.       -  .039     -  .001     -  .005     -  .005
102006030   +      598020.       +  .040     +  .001     +  .006     +  .005
            -      351000.       -  .022     -  .001     -  .003     -  .003

102007000   +      142990.       +  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
            -      142990.       -  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE

102007010   +      125700.       +  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
            -      125700.       -  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
102007020   +       68100.       +  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
            -       68100.       -  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
102007030   +        2800.       +  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
            -        2800.       -  .000     NEGLIGIBLE  NEGLIGIBLE  NEGLIGIBLE
```

Table 2-4-a. 1976 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101002000	403380000.	4.880	.073	.206	4.185
101002010	45830000.	.550	.007	.023	.793
101002020	289300000.	2.733	.052	.145	2.966
101002021	152490000.	.981	.023	.076	1.563
101002022	61370000.	.786	.009	.031	.629
101002023	60450000.	.774	.009	.030	.620
101002024	14990000.	.192	.011	.007	.154
101002030	55870000.	1.500	.008	.028	.207
101002040	4200000.	.030	.002	.004	.084
101002050	1810000.	.013	.001	.002	.025
101002060	190000.	.002	.000	.000	.007
101002070	1635800.	.015	.000	.001	.024
101002080	440000.	.003	.000	.000	.006
101002090	2350000.	.017	.001	.002	.022
101002100	30000.	.000	.000	.000	.000
101002110	0.	0.000	0.000	0.000	0.000
101002120	1728700.	.016	.000	.001	.032
101004000	19940000.	.620	.020	.030	.080
101004010	19690000.	.613	.020	.030	.079
101004011	7876000.	.149	.008	.012	.032
101004012	5700000.	.216	.006	.009	.023
101004013	5700000.	.216	.006	.009	.023
101004014	414000.	.031	.000	.001	.002
101004020	240000.	.007	.000	.000	.001
101004030	10000.	.000	.000	.000	.000
101005000	0.	0.000	0.000	0.000	0.000
101005010	0.	0.000	0.000	0.000	0.000
101005020	0.	0.000	0.000	0.000	0.000
101005030	0.	0.000	0.000	0.000	0.000

Table 2-4-a. 1976 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 2

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101006000	2792100.	.537	.001	.024	.021
101006010	2739000.	.527	.001	.023	.021
101006011	724000.	.078	.000	.006	.005
101006012	1127000.	.242	.001	.010	.008
101006013	806000.	.173	.000	.007	.006
101006014	82000.	.035	.000	.001	.001
101006020	49000.	.009	.000	.000	.000
101006030	4100.	.001	.000	.000	.000
101007000	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007010	90390.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007020	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
101007030	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102002000	64451000.	.644	.026	.057	1.129
102002010	5910000.	.071	.001	.003	.090
102002020	6970000.	.066	.001	.003	.140
102002030	7000000.	.188	.001	.004	.034
102002040	26540000.	.190	.013	.027	.536
102002050	1180000.	.008	.001	.001	.027
102002060	5020000.	.036	.003	.003	.083
102002070	290000.	.003	.000	.000	.014
102002080	730000.	.007	.000	.000	.016
102002090	9981000.	.071	.005	.010	.183
102002100	310000.	.001	.000	.002	.002
102002110	130000.	.000	.000	.001	.002
102002120	0.	0.000	0.000	0.000	0.000
102002130	390000.	.002	.001	.002	.004
102004000	12750000.	.268	.019	.026	.147
102004010	8060000.	.169	.012	.016	.093
102004020	4130000.	.087	.006	.008	.047

Table 2-4-a. 1976 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

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                        EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE  3
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976       RUN DATE= MAR 22,1977
 MODIFIED          TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)        NOX           HC              CO             PART
102004030          560000.         .012          .001            .001           .006
102005000         7440000.         .156          .011            .015           .056
102005010         5446000.         .115          .008            .011           .041
102005020         1774000.         .037          .003            .004           .013
102005030          200000.         .004          .000            .000           .002
102006000         3200000.         .267          .005            .028           .030
102006010         1920000.         .156          .003            .016           .017
102006020          861000.         .070          .001            .007           .008
102006030          499000.         .041          .001            .004           .004
102007000         1749300.         .000      NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
102007010         1257000.         .000      NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
102007020          464000.         .000      NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
102007030           28260.         .000      NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE
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Table 2-4-b. 1976 EXTERNAL COMBUSTION UNCERTAINTIES

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                       EXTERNAL COMBUSTION, BOILER CATEGORY                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976        RUN DATE= MAR 22,1977
 MODIFIED         TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX              HC               CO              PART
101002000   +   15024000.       +  .416       +  .101        +  .072       +  .482
            -   15024000.       -  .416       -  .015        -  .048       -  .482

101002019   +    6609800.       +  .122       +  .005        +  .018       +  .276
            -    6609800.       -  .122       -  .004        -  .012       -  .276
101002020   +   11953000.       +  .207       +  .101        +  .066       +  .385
            -   11953000.       -  .207       -  .013        -  .044       -  .385

101002021   +   10369000.       +  .189       +  .018        +  .057       +  .334
            -   10369000.       -  .189       -  .012        -  .038       -  .334
101002022   +    4164300.       +  .151       +  .071        +  .023       +  .134
            -    4164300.       -  .151       -  .005        -  .015       -  .134
101002023   +    4122300.       +  .149       +  .070        +  .023       +  .133
            -    4122300.       -  .149       -  .005        -  .015       -  .133
101002024   +    1020000.       +  .037       +  .008        +  .006       +  .033
            -    1020000.       -  .037       -  .001        -  .004       -  .033

101002030   +    6177400.       +  .275       +  .008        +  .021       +  .065
            -    6177400.       -  .275       -  .004        -  .014       -  .065
101002040   +     921950.       +  .008       +  .002        +  .003       +  .030
            -     921950.       -  .008       -  .002        -  .002       -  .030
101002050   +     232590.       +  .002       +  .001        +  .001       +  .011
            -     232590.       -  .002       -  .001        -  .001       -  .011
101002060   +      43174.       +  .001       +  .000        +  .000       +  .004
            -      43174.       -  .001       -  .000        -  .000       -  .004
101002070   +     102960.       +  .003       +  .003        +  .001       +  .003
            -     102960.       -  .003       -  .000        -  .000       -  .003
101002080   +      92195.       +  .001       +  .000        +  .000       +  .002
            -      92195.       -  .001       -  .000        -  .000       -  .002
101002090   +     205910.       +  .003       +  .001        +  .002       +  .009
            -     205910.       -  .003       -  .001        -  .001       -  .009
101002100   +          0.       +  .000       +  .000        +  .000       +  .000
            -          0.       -  .000       -  .000        -  .000       -  .000
101002110   +          0.       + 0.000       + 0.000        + 0.000       + 0.000
            -          0.       - 0.000       - 0.000        - 0.000       - 0.000
101002120   +     138920.       +  .003       +  .000        +  .001       +  .044
            -     138920.       -  .003       -  .000        -  .000       -  .044
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Table 2-4-b. 1976 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)							
				NOX		HC		CO		PART
101004000	+	2516400.	+	.103	+	.009	+	.014	+	.010
	-	2516400.	-	.103	-	.006	-	.009	-	.010
101004010	+	2516400.	+	.103	+	.009	+	.014	+	.010
	-	2516400.	-	.103	-	.006	-	.009	-	.010
101004011	+	1740000.	+	.045	+	.006	+	.009	+	.007
	-	1740000.	-	.045	-	.004	-	.006	-	.007
101004012	+	1295600.	+	.066	+	.004	+	.007	+	.005
	-	1295600.	-	.066	-	.003	-	.005	-	.005
101004013	+	1273500.	+	.065	+	.004	+	.007	+	.005
	-	1273500.	-	.065	-	.003	-	.005	-	.005
101004014	+	67082.	+	.008	+	.000	+	.000	+	.000
	-	67082.	-	.008	-	.000	-	.000	-	.000
101004020	+	0.	+	.002	+	.000	+	.000	+	0.000
	-	0.	-	.002	-	.000	-	.000	-	0.000
101004030	+	0.	+	.000	+	.000	+	.000	+	0.000
	-	0.	-	.000	-	.000	-	.000	-	0.000
101005000	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005010	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005020	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101005030	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101006000	+	875870.	+	.176	+	.001	+	.012	+	.007
	-	875870.	-	.176	-	.001	-	.010	-	.007
101006010	+	875540.	+	.176	+	.001	+	.012	+	.007
	-	875540.	-	.176	-	.001	-	.010	-	.007
101006011	+	393580.	+	.043	+	.000	+	.006	+	.003
	-	393580.	-	.043	-	.000	-	.005	-	.003

Table 2-4-b. 1976 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 3

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC		CO		PART
101006012	+	635310.	+	.130	+	.001	+	.009	+	.005
	-	635310.	-	.130	-	.000	-	.007	-	.005
101006013	+	453850.	+	.098	+	.000	+	.006	+	.003
	-	453850.	-	.098	-	.000	-	.005	-	.003
101006014	+	45398.	+	.020	+	.000	+	.001	+	.000
	-	45398.	-	.020	-	.000	-	.001	-	.000
101006020	+	24000.	+	.005	+	.000	+	.000	+	.000
	-	24000.	-	.005	-	.000	-	.000	-	.000
101006030	+	2100.	+	.000	+	.000	+	.000	+	.000
	-	2100.	-	.000	-	.000	-	.000	-	.000
101007000	+	15220.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	15220.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
101007010	+	15220.	+	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
	-	15220.	-	.000		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
101007020		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
101007030		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE		NEGLIGIBLE
102002000	+	7378300.	+	.089	+	.011	+	.023	+	.209
	-	7378300.	-	.089	-	.011	-	.016	-	.209
102002010	+	1055900.	+	.017	+	.001	+	.002	+	.024
	-	1055900.	-	.017	-	.000	-	.002	-	.024
102002020	+	4202900.	+	.041	+	.001	+	.003	+	.089
	-	4202900.	-	.041	-	.001	-	.003	-	.089
102002030	+	1929400.	+	.059	+	.001	+	.003	+	.013
	-	1929400.	-	.059	-	.001	-	.002	-	.013
102002040	+	5064200.	+	.044	+	.010	+	.021	+	.164
	-	5064200.	-	.044	-	.010	-	.014	-	.164
102002050	+	130920.	+	.002	+	.000	+	.001	+	.006
	-	130920.	-	.002	-	.000	-	.001	-	.006
102002060	+	1070600.	+	.009	+	.002	+	.004	+	.026
	-	1070600.	-	.009	-	.002	-	.003	-	.026

Table 2-4-b. 1976 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                      EXTERNAL COMBUSTION, BOILER CATEGORY                              PAGE  4
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976              RUN DATE= MAR 22,1977
 MODIFIED        TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)          NOX                 HC                 CO                PART
102002070    +     46518.        +  .001          +  .000          +  .000          +  .004
             -     46518.        -  .001          -  .000          -  .000          -  .004
102002080    +    438630.        +  .006          +  .000          +  .000          +  .010
             -    438630.        -  .006          -  .000          -  .000          -  .010
102002090    +   2218500.        +  .019          +  .004          +  .008          +  .086
             -   2218500.        -  .019          -  .004          -  .005          -  .086
102002100    +     46518.        +  .001          +  .000          +  .001          +  .001
             -     46518.        -  .001          -  .000          -  .001          -  .001
102002110    +     18000.        +  .000          +  .000          +  .000          +  .001
             -     18000.        -  .000          -  .000          -  .000          -  .001
102002120    +         0.        + 0.000          + 0.000          + 0.000          + 0.000
             -         0.        - 0.000          - 0.000          - 0.000          - 0.000
102002130    +     86348.        +  .001          +  .000          +  .001          +  .002
             -     86348.        -  .001          -  .000          -  .001          -  .002

102004000    +   1213000.        +  .101          +  .011          +  .013          +  .014
             -   1213000.        -  .101          -  .007          -  .009          -  .014

102004010    +   1136500.        +  .090          +  .009          +  .012          +  .013
             -   1136500.        -  .090          -  .006          -  .008          -  .013
102004020    +    420290.        +  .045          +  .005          +  .006          +  .005
             -    420290.        -  .045          -  .003          -  .004          -  .005
102004030    +     56682.        +  .006          +  .001          +  .001          +  .001
             -     56682.        -  .006          -  .000          -  .001          -  .001

102005000    +   1049700.        +  .066          +  .007          +  .008          +  .008
             -   1049700.        -  .066          -  .005          -  .006          -  .008

102005010    +   1008000.        +  .062          +  .006          +  .008          +  .008
             -   1008000.        -  .062          -  .004          -  .006          -  .008
102005020    +    290690.        +  .020          +  .002          +  .003          +  .002
             -    290690.        -  .020          -  .001          -  .002          -  .002
102005030    +     35063.        +  .002          +  .000          +  .000          +  .000
             -     35063.        -  .002          -  .000          -  .000          -  .000

102006000    +   1226100.        +  .108          +  .003          +  .017          +  .011
             -   1226100.        -  .116          -  .002          -  .014          -  .011
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Table 2-4-b. 1976 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                      EXTERNAL CCMBUSTION, BOILER CATEGORY                    PAGE  5
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX             HC              CO             PART

102006010   +    1109100.       +  .097       +  .003       +  .015       +  .010
            -    1109100.       -  .105       -  .002       -  .012       -  .010
102006020   +     452200.       +  .040       +  .001       +  .007       +  .004
            -     452200.       -  .044       -  .001       -  .005       -  .004
102006030   +     261960.       +  .023       +  .001       +  .004       +  .002
            -     261960.       -  .025       -  .001       -  .003       -  .002

102007000   +     142990.       +  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -     142990.       -  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

102007010   +     125700.       +  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -     125700.       -  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
102007020   +      68100.       +  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -      68100.       -  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
102007030   +       2800.       +  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -       2800.       -  .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
```

Table 2-5-a. 1981 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
101002000	474040000.	4.609	.085	.242	3.929
101002010	45830000.	.435	.007	.023	.626
101002020	350300000.	2.690	.063	.175	2.960
101002021	184640000.	.966	.028	.092	1.560
101002022	74320000.	.774	.011	.037	.628
101002023	73200000.	.762	.011	.037	.618
101002024	18140000.	.189	.014	.009	.153
101002030	64820000.	1.400	.010	[illegible]	.182
101002040	[illegible]	.024	.002	.004	.062
101002050	1810000.	.010	.001	.002	.018
101002060	190000.	.002	.000	.000	.004
101002070	1978800.	.015	.000	.001	.024
101002080	440000.	.003	.000	.000	.005
101002090	2350000.	.013	.001	.002	.016
101002100	30000.	.000	.000	.000	.000
101002110	0.	0.000	0.000	0.000	0.000
101002120	2093200.	.016	.000	.001	.032
101004000	28590000.	.120	.029	.043	.114
101004010	28340000.	.119	.028	.043	.113
101004011	11336000.	.041	.011	.017	.045
101004012	8200000.	.036	.008	.012	.033
101004013	8200000.	.036	.008	.012	.033
101004014	604000.	.005	.001	.001	.002
101004020	240000.	.001	.000	.000	[illegible]
101004030	10000.	.000	.000	.000	.000
101005000	0.	0.000	0.000	0.000	0.000
101005010	0.	0.000	0.000	0.000	0.000
101005020	0.	0.000	0.000	0.000	0.000
101005030	0.	0.000	0.000	0.000	0.000

Table 2-5-a. 1981 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

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                    EXTERNAL COMBUSTION, BOILER CATEGORY                    PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED        TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)        NOX           HC            CO          PART
101006000      1785600.         .057          .001          .015          .013

101006010      1754000.         .056          .001          .015          .013

101006011       464000.         .012          .000          .004          .003
101006012       722000.         .024          .000          .006          .005
101006013       516000.         .017          .000          .004          .004
101006014        52000.         .003          .000          .000          .000

101006020        29000.         .001          .000          .000          .000
101006030         2600.         .000          .000          .000          .000

101007000        90390.         .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

101007010        90390.         .000      NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
101007020    NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
101007030    NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

102002000    100540000.         .816          .040          .089         1.290

102002010      8760000.         .083          .001          .004          .103
102002020     12420000.         .095          .002          .006          .200
102002030     11500000.         .248          .002          .006          .040
102002040     43640000.         .250          .022          .044          .643
102002050      1930000.         .011          .001          .002          .030
102002060      8270000.         .047          .004          .008          .090
102002070       440000.         .004          .000          .000          .013
102002080      1280000.         .010          .000          .001          .022
102002090     10966000.         .063          .005          .011          .139
102002100       510000.         .002          .001          .003          .003
102002110       180000.         .000          .000          .001          .002
102002120            0.        0.000         0.000         0.000         0.000
102002130       640000.         .003          .001          .003          .005

102004000     16000000.         .096          .024          .032          .184

102004010     10110000.         .061          .015          .020          .116
102004020      5180000.         .031          .008          .010          .060
```

Table 2-5-a. 1981 EXTERNAL COMBUSTION EMISSIONS AND CHARGE RATES (Continued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 3

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
102004030	710000.	.004	.001	.001	.008
102005000	9340000.	.056	.014	.019	.070
102005010	6866000.	.041	.010	.014	.051
102005020	2224000.	.013	.003	.004	.017
102005030	250000.	.002	.000	.001	.002
102006000	2080000.	.123	.003	.018	.019
102006010	1220000.	.072	.002	.010	.011
102006020	546000.	.032	.001	.005	.005
102006030	314000.	.019	.000	.003	.003
102007000	1749300.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007010	1257000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007020	464000.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
102007030	28260.	.000	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE

Table 2-5-b. 1981 EXTERNAL COMBUSTION UNCERTAINTIES

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		NOX		HC		CO		PART
			EMISSIONS (MILLIONS OF TONS / YEAR)							
101002000	+	34654000.	+	.872	+	.123	+	.087	+	.913
	-	34654000.	-	.872	-	.018	-	.059	-	.913
101002010	+	16919000.	+	.240	+	.006	+	.019	+	.336
	-	16919000.	-	.240	-	.004	-	.014	-	.334
101002020	+	26300000.	+	.549	+	.122	+	.081	+	.844
	-	26300000.	-	.549	-	.016	-	.055	-	.844
101002021	+	22813000.	+	.362	+	.022	+	.070	+	.732
	-	22813000.	-	.362	-	.014	-	.048	-	.732
101002022	+	9159200.	+	.289	+	.085	+	.028	+	.295
	-	9159200.	-	.289	-	.006	-	.019	-	.295
101002023	+	9074100.	+	.285	+	.084	+	.028	+	.290
	-	9074100.	-	.285	-	.006	-	.019	-	.290
101002024	+	2247200.	+	.071	+	.010	+	.007	+	.072
	-	2247200.	-	.071	-	.002	-	.005	-	.072
101002030	+	14709000.	+	.634	+	.008	+	.025	+	.082
	-	14709000.	-	.634	-	.005	-	.018	-	.082
101002040	+	2408300.	+	.017	+	.002	+	.004	+	.045
	-	2408300.	-	.017	-	.002	-	.003	-	.044
101002050	+	568860.	+	.005	+	.001	+	.001	+	.012
	-	568860.	-	.005	-	.001	-	.001	-	.011
101002060	+	112450.	+	.001	+	.000	+	.000	+	.004
	-	112450.	-	.001	-	.000	-	.000	-	.004
101002070	+	245150.	+	.006	+	.000	+	.001	+	.006
	-	245150.	-	.006	-	.000	-	.001	-	.006
101002080	+	240830.	+	.002	+	.000	+	.000	+	.003
	-	240830.	-	.002	-	.000	-	.000	-	.003
101002090	+	490310.	+	.006	+	.001	+	.002	+	.008
	-	490310.	-	.006	-	.001	-	.001	-	.010
101002100	+	0.	+	.000	+	.000	+	.000	+	.000
	-	0.	-	.000	-	.000	-	.000	-	.000
101002110	+	0.	+	0.000	+	0.000	+	0.000	+	0.000
	-	0.	-	0.000	-	0.000	-	0.000	-	0.000
101002120	+	327570.	+	.006	+	.000	+	.001	+	.030
	-	327570.	-	.006	-	.000	-	.001	-	.032

Table 2-5-b. 1981 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                          EXTERNAL COMBUSTION, BOILER CATEGORY                    PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
 MODIFIED          TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)           NOX             HC              CO            PART
101004000   +     5192100.        +  .178         +  .013         +  .020        +  .021
            -     5192100.        -  .023         -  .010         -  .014        -  .021

101004010   +     5192100.        +  .178         +  .013         +  .020        +  .021
            -     5192100.        -  .023         -  .010         -  .014        -  .021

101004011   +     3567900.        +  .078         +  .009         +  .014        +  .014
            -     3567900.        -  .013         -  .007         -  .010        -  .014
101004012   +     2703800.        +  .112         +  .007         +  .010        +  .011
            -     2703800.        -  .013         -  .005         -  .007        -  .011
101004013   +     2628200.        +  .112         +  .007         +  .010        +  .011
            -     2628200.        -  .013         -  .005         -  .007        -  .011
101004014   +      100000.        +  .016         +  .000         +  .001        +  .000
            -      100000.        -  .003         -  .000         -  .000        -  .000

101004020   +           0.        +  .003         +  .000         +  .000        + 0.000
            -           0.        - 0.000         -  .000         -  .000        - 0.000
101004030   +           0.        +  .000         +  .000         +  .000        + 0.000
            -           0.        - 0.000         -  .000         -  .000        - 0.000

101005000   +           0.        + 0.000         + 0.000         + 0.000        + 0.000
            -           0.        - 0.000         - 0.000         - 0.000        - 0.000

101005010   +           0.        + 0.000         + 0.000         + 0.000        + 0.000
            -           0.        - 0.000         - 0.000         - 0.000        - 0.000
101005020   +           0.        + 0.000         + 0.000         + 0.000        + 0.000
            -           0.        - 0.000         - 0.000         - 0.000        - 0.000
101005030   +           0.        + 0.000         + 0.000         + 0.000        + 0.000
            -           0.        - 0.000         - 0.000         - 0.000        - 0.000

101006000   +     2318500.        +  .083         +  .001         +  .021        +  [illegible]
            -     1003200.        -  .032         -  .001         -  .009        -  .008

101006010   +     2317600.        +  .083         +  .001         +  .021        +  .017
            -     1002800.        -  .032         -  .001         -  .009        -  .008

101006011   +     1041300.        +  .028         +  .001         +  .009        +  .008
            -      464000.        -  .012         -  .000         -  .004        -  .003
```

Table 2-5-b. 1981 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

```
                         EXTERNAL COMBUSTION, BOILER CATEGORY                         PAGE  3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)         NOX             HC              CO            PART

101006012   +     1682000.      +  .063       +  .001       +  .015       +  .013
            -      722000.      -  .024       -  .000       -  .006       -  .005
101006013   +     1201400.      +  .045       +  .001       +  .011       +  .009
            -      516000.      -  .017       -  .000       -  .004       -  .004
101006014   +      120150.      +  .009       +  .000       +  .001       +  .001
            -       52000.      -  .003       -  .000       -  .000       -  .000

101006020   +       64000.      +  .002       +  .000       +  .001       +  .000
            -       29000.      -  .001       -  .000       -  .000       -  .000
101006030   +        5600.      +  .000       +  .000       +  .000       +  .000
            -        2600.      -  .000       -  .000       -  .000       -  .000

101007000   +       15220.      +  .000       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -       15220.      -  .000       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

101007010   +       15220.      +  .000       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
            -       15220.      -  .000       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
101007020      NEGLIGIBLE       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
               NEGLIGIBLE       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
101007030      NEGLIGIBLE       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE
               NEGLIGIBLE       NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

102002000   +    14080000.      +  .197       +  .018       +  .037       +  .327
            -    14080000.      -  .197       -  .018       -  .027       -  .328

102002010   +     2529900.      +  .042       +  .001       +  .004       +  .044
            -     2529900.      -  .042       -  .001       -  .003       -  .044
102002020   +     5275800.      +  .053       +  .002       +  .005       +  .112
            -     5275800.      -  .053       -  .001       -  .004       -  .112
102002030   +     4512200.      +  .138       +  .001       +  .005       +  .023
            -     4512200.      -  .138       -  .001       -  .004       -  .023
102002040   +    11286000.      +  .118       +  .017       +  .035       +  .285
            -    11286000.      -  .118       -  .017       -  .025       -  .285
102002050   +      327570.      +  .005       +  .001       +  .001       +  .013
            -      327570.      -  .005       -  .001       -  .001       -  .013
102002060   +     2270600.      +  .023       +  .003       +  .007       +  .044
            -     2270600.      -  .023       -  .003       -  .005       -  .048
```

Table 2-5-b. 1981 EXTERNAL COMBUSTION UNCERTAINTIES (Cc ·inued)

EXTERNAL COMBUSTION, BOILER CATEGORY PAGE 4

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
102002070	+	113770.	.002	.000	.000	.007
	-	113770.	.002	.000	.000	.008
102002080	+	624820.	.006	.000	.001	.013
	-	624820.	.006	.000	.000	.013
102002090	+	3248600.	.031	.004	.009	.092
	-	3248600.	.031	.004	.006	.096
102002100	+	113770.	.001	.000	.001	.003
	-	113770.	.001	.000	.001	.002
102002110	+	48000.	.000	.000	.001	.001
	-	48000.	.000	.000	.001	.001
102002120	+	0.	0.000	0.000	0.000	0.000
	-	0.	0.000	0.000	0.000	0.000
102002130	+	224890.	.003	.001	.002	.004
	-	224890.	.002	.001	.002	.004
102004000	+	1832900.	.165	.013	.016	.021
	-	1832900.	.029	.009	.012	.021
102004010	+	1753200.	.146	.012	.015	.020
	-	1753200.	.026	.008	.011	.020
102004020	+	527580.	.075	.006	.007	.006
	-	527580.	.013	.004	.005	.006
102004030	+	87002.	.010	.001	.001	.001
	-	87002.	.002	.001	.001	.001
102005000	+	2344200.	.105	.009	.011	.018
	-	2344200.	.022	.006	.009	.018
102005010	+	2241800.	.160	.009	.011	.017
	-	2241800.	.021	.006	.008	.017
102005020	+	680730.	.032	.003	.003	.005
	-	680730.	.007	.002	.003	.005
102005030	+	79361.	.004	.000	.000	.001
	-	79361.	.001	.000	.000	.001
102006000	+	3013100.	.186	.003	.027	.027
	-	1373000.	.081	.002	.012	.012

Table 2-5-b. 1981 EXTERNAL COMBUSTION UNCERTAINTIES (Continued)

```
                           EXTERNAL C CMBUSTION, BOILER CATEGORY                    PAGE  5
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981                 RUN DATE= MAR 22,1977
                                          EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED          TACRP                                 HC               CO              PART
  SCC          (SCC UNITS)            NOX
102006010   +    2686900.       +  .166       +  .004         +  .024         +  .024
            -    1220000.       -  .072       -  .002         -  .010         -  .011
102006020   +    1180200.       +  .073       +  .002         +  .011         +  .011
            -     546000.       -  .032       -  .001         -  .005         -  .005
102006030   +     682640.       +  .042       +  .001         +  .006         +  .006
            -     314000.       -  .019       -  .000         -  .003         -  .003

102007000   +     142990.       +  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
            -     142990.       -  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE

102007010   +     125700.       +  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
            -     125700.       -  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
102007020   +      68100.       +  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
            -      68100.       -  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
102007030   +       2800.       +  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
            -       2800.       -  .000       NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE
```

tape was obtained from the NEDS data bank containing card images of all stored point source data for utility and industrial boilers, SCC 1-01-001-01 through 1-02-999-99 (see Ref. 2-3 for definition of terms and SCC categories). It was necessary to write computer programs to extract, summarize, and check the data contained on this tape. Much of the literature search and literature data analyses were completed by the time the NEDS tape data became one in which complete data acquisition and projection was first accomplished from existing sources in the published (and some unpublished) literature. The NEDS tape data was used as a second data source, both to accomplish a further breakdown of some of the larger source categories into more detailed firing types and to provide a means of estimating the accuracy, or uncertainty, of the data.

In the special case of process gas combustion, the situation was reversed in that little or no data existed in the literature but the NEDS data indicated large fuel usage rates and NO_x emissions. In that case, only the NEDS tape data were examined in detail, and uncertainties were derived from that data analysis alone. As discussed in Section 2.1, the errors found were sufficiently large to reduce that category to negligible proportions.

The SCC external combustion (boilers) category was subdivided according to the fuels selected for study within this category, which are represented by 58 MSCC categories. In order to accomplish the type of linear projections into the future, with cited uncertainties, as described in Section 1, a total of 39 distinct input numbers had to be generated for each MSCC. Thus, for this category alone, a total of 2,262 separate data entries had to be considered.

In general, initial efforts were made, from data in the literature, to estimate current values of fuel usage rates and emission factors. The NEDS data were used to improve and confirm these estimates, provide further breakdowns into finer categories, and estimate uncertainties in current data levels. Methods of projecting data into the future could only be derived from the literature and other unpublished data sources. All data sources were also used to estimate uncertainties in the projection methods and the resulting levels projected to 1980. The resulting data level estimates and uncertainties were then used to derive the linear slopes and the uncertainties in these slopes.

Since the literature search and analyses of data from the literature provided a major source of current data and the only source of projection data and methods, these data and analyses are discussed in depth in Section 2.3. In most cases, the data finally used in the projections were reviewed and somewhat modified (or established) by subsequent comparison with NEDS tape derived data. A discussion of the NEDS data is contained in Section 2.4.

2.4 DATA ANALYSIS FROM LITERATURE

Data in the literature can be divided into the source categories of utility boilers and industrial boilers. Data concerning these two sources are sufficiently different, both in depth and type, that separate data sources and analyses were necessary to derive the desired data. Further, PART control equipment efficiency and degree of application data represented a special effort. Therefore, studies in these three areas were generally conducted separately.

2.4.1 Fuel Usage, NO_x, HC, and CO Emissions in and from Utility Boilers

An Edison Electric Institute (EEI) survey (Ref. 2-4) of several hundred utility steam generator units provided data on boiler firing type, fuel type, and unit megawatt electrical design capacity. This survey provided the basis for a proportional breakdown of burner firing types categorized as follows: tangential, opposed wall, front or back wall, cyclone, and vertical. The sample contained in the EEI survey was sufficiently large to be deemed representative of the overall utility industry.

Since many utility stations were shown to have multifuel operating capability, a further time-related refinement was required. Annual fuel usage statistics for multifuel-fired plants were sampled (Ref. 2-5). The sample size chosen for analysis of these data was arbitrarily limited to utilities with power capability exceeding ~400 MW. This was done for reasons of manageability. The average proportions of annual usage of each fuel as reported for these stations (coal/oil, oil/gas, coal/oil/gas) were acquired. In the analysis, data were weighted to account for differences in fuel heating values. The proportional statistics for adjusted fuel consumption and breakdown by firing type were then used to develop a summary breakdown expressed as the percent of total energy output.

The total estimated 1973 electrical energy output of the United States was 1.88×10^{12} kW-hr (Ref. 2-6). The fossil-fueled steam electric energy value of 1.43×10^{12} kW-hr is about 76 percent of the total annual output (Refs. 2-7 and 2-8). An average plant net heating rate of 10,350 Btu/kW-hr was selected as representative of the industry (Refs. 2-9 and 2-10). This equals an electrical conversion efficiency of 33 percent, a figure which is somewhat below the most efficient of recently installed large units but which conservatively accounts for many of the older units still in operation.

With these factors, tables were derived for electrical and heat energy generation by firing type. The heating values for coal, oil, and gas, taken as 25×10^6 Btu/ton, 142,800 Btu/gal, and 1050 Btu/cu ft, respectively, enabled the determination of fuel consumption by firing type.

Emission factors published by the Environmental Protection Agency (EPA) (Ref. 2-11) are given in pounds of pollutants per unit fuel usage and are categorized by source. Additional data on tangential-fired furnace emissions were obtained from other sources. (Refs. 2-12 and 2-13). The product of fuel usage multiplied by the appropriate emission factor (CO, HC, NO_x) provided the detailed data breakdown for the stationary power plant emission inventory by boiler firing type.

Projections of emissions for 1980 involved establishment of expected fuel usage figures for that year (Ref. 2-8). However, current drastic changes in socioeconomic conditions may strongly affect actual overall electric energy demand in 1980 as well as the fuel mix used to supply that demand. The differences between current fuel usage and the 1980 usage estimates represent new construction.

Boiler construction figures by firing type were not readily obtainable in the short time span of the study. Speculative consideration was given to recent trends showing that Combustion Engineering, supplier of tangential furnaces, has shown increasing market penetration and is currently reported (Ref. 2-14) to be controlling about 43 percent of the new boiler market. In addition, multifuel firing capability, already in common practice, tends to favor a shift in this direction with coal remaining as the predominant fuel, especially in view of uncertainties in the future availability of oil and gas. Thus, the 1980 fuel usage breakdown, reflecting these considerations, is based on the assumption that one half of the new construction for fuel consumption (coal, oil, and gas) will be allocated to tangential-fired units, and the remaining one half will be proportioned as in 1973. The incremental fuel usage values were summed to the 1973 usages to obtain 1980 projections.

The new construction is expected to fulfill the EPA national emissions requirements already legislated (Ref. 2-15). It is further anticipated that improvements in existing units will be forthcoming. Exploratory efforts concerning the feasibility of reduced NO_x by means of combustion modifications have shown promise in several investigations (Refs. 2-12, 2-16, and 2-17). Therefore, slightly lower emission factors were assumed for NO_x emitted from existing facilities. Other studies which have been conducted in this field are reported in Refs. 2-18 through 2-20.

For all coal-fired furnaces, it was assumed that the 1980 NO_x emission factors could be reduced by 25 percent from the 1973 factors listed in Ref. 2-11. NO_x emission factors estimated for coal in 1980, were 13.5 lb/ton for all pulverized firing and 41 lb/ton for cyclone furnaces. The 1973 NO_x emission factors for gas and oil, converted to parts per million (PPM) in the flue gas, are 273 for oil and 238 for gas in tangential-fired boilers and 572 for oil and 476 for gas in other firing types. Recent efforts to reduce NO_x emissions in utility boilers indicate that simple, practical combustion modifications can reduce NO_x emissions in both gas- and oil-fired utility boilers at least to 200 parts per million. On the assumption that this technology is currently available and will be widely implemented by 1980, NO_x emission factors of 36 lb/10^3 gal of oil and 250 lb/10^6 cu ft of gas in all firing types were estimated.

Although there is little well-documented information in the technical literature, the popular media and personal observation of some public and private utilities indicate that natural gas may disappear as a fuel for electric generation well before 1980. Many utilities are already experiencing long seasonal periods during which natural gas fuels are not available. Even the highly publicized Alaskan natural gas supply, when fully developed, is expected to deliver less than 10 percent of the current demand in utility and industrial boilers alone. For these reasons, projected natural gas usage in utility and industrial boilers was estimated to decrease at a slope (and slope uncertainty) which indicates zero usage as early as 1978. Considering the unsubstantiated quality of this type of popular data, however, the uncertainty in this negative slope is large. The projected electrical demand which would have been supplied by natural gas combustion was shifted to coal-burning utilities and coal- and oil-burning industrial boilers.

In general, HC and CO emissions from external combustion boilers are low and usually well below the limits of any foreseen regulations. For this reason, no effort was made to project changes in HC and CO emission factors. In all cases in this category, HC and CO slopes were considered equal to zero.

2.4.2 Fuel Usage, NO_x, HC, and CO Emissions in and from Industrial Boilers

The three major pieces of information needed to calculate the industrial boiler emissions are the installed boiler capacity, the consumption of each type of fuel, and the emission factors. Within the time constraints of this study, only a limited literature search and a survey of potential information sources were possible. For boiler capacity data, the only source located was Ref. 2-21, in which were several tables based on information in Ref. 2-22. In those tables, industrial boiler capacities were given for 1967, with projections to 1975 and 1980, in terms of total steam generation in pounds per hour. An estimate was made of the breakdown of the 1967 total capacity into three size categories: 10 to 100, 100 to 250, and

250 to 500 KPPH.* Sales data from Refs. 2-23 and 2-24 were used to project how the total capacity would be divided into these three size ranges in 1973 and 1980.

The Ehrenfeld 1967 data given in Ref. 2-18 also included coal, oil, and natural gas annual consumption for the industrial boilers. Using heating values for the coal (25×10^6 Btu/ton), oil (6×10^6 Btu/bbl), and gas (1050 Btu/cu ft) and assuming 1000 Btu/lb heat content of steam, it was possible to relate capacity data in heat output per hour to the annual heat input. A factor of 3800 was derived, an average factor, in hours per year at rated capacity operation. Lacking any later data along these lines, this factor was used for all subsequent year calculations to relate boiler capacities to heat input and thus to total annual fuel consumption.

Next, the total fuel consumption derived for 1973 and 1980 was divided among coal, oil, and gas. The boiler population data in Ref. 2-23 (for 1972) were used to estimate the 1973 fuel usage split. Although these data are boiler number percentages rather than capacity percentages, there are sufficient size categories that the two percentages should not be widely different. For 1980, Battelle is currently working on such an estimate, taking into account the energy supply situation; however, results were not available in time for this study. Therefore, a best estimate was made on the basis that the use of coal would show a sharp rise, both from new boilers and conversion of existing units, with a smaller rise in oil consumption and a decrease in natural gas use. A rough guideline was the fuel breakdown given in Ref. 2-23 for 1950 when coal was widely used in industrial boilers. A further consideration was the greater tendency toward coal in large units compared to the smaller sizes.

With boiler capacities and fuel consumption estimates in hand, the emissions of NO_x, CO, and HC for 1968 and 1973 were calculated using the emission factors of Ref. 2-11. Emission factors for NO_x from gas-fired boilers, given in Ref. 2-11 for industrial boilers, range from 120 to 230 lb/10^6 cu ft from the smallest to the largest boilers. Rather than trying to

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[*] KPPH = thousands of pounds of steam per hour.

interpolate and use multiple factors, an arithmetic average of 175 was applied to the total gas consumption. Since NO_x emissions from natural gas combustion represent only about 20 percent of the total, an error in using an average emission factor should not significantly affect the total emissions.

In estimating probable NO_x emission factors for 1980, it was noted that there are currently no NO_x regulations for industrial boilers other than for new units larger than 250 million Btu/hr heat input but that some sort of control appears likely in the near future. Much of the NO_x control technology developed for utility boilers should be directly applicable, but the larger question concerns the degree to which new regulations will be met in industrial boilers by 1980. For the 1980 projections, it was assumed that the NO_x emission factors for coal firings will be reduced by 25 percent (as in the case of utility boilers) but that NO_x emissions from gas and oil firings will be reduced by 50 percent, rather than the 58 to 65 percent reduction which appears likely for utility boilers. A summary of the 1973 NO_x emission factors and those assumed in this study for 1980, for both utility and industrial boilers, is as follows:

Fuel	Emission Factor Unit	Use	Emission Factor			
			Utilities		Industrial	
			1973	1980	1973	1980
Coal	lb/ton	General	18	13.5	18	13.5
	lb/ton	Cyclone	55	41	55	41
	lb/ton	Stoker	-	-	15	11.25
Oil	lb/1000 gal	Tangential	50	36	40	20
	lb/1000 gal	Other	105	36	80	40
Natural Gas	lb/million cu ft	Tangential	300	250	180	90
	lb/million cu ft	Other	600	250	180	90

As in the utility boiler category, HC and CO emissions were considered currently satisfactory, and the 1980 emissions factor used were unchanged from those of Ref. 2-11.

2.4.3 PART Emissions from Utility and Industrial Boilers

The PART emission category is different from those of NO_x, CO, and HC in that PART emissions are not only a function of the fuel type but are also strongly dependent on the PART control equipment used. PART emissions from gas- and oil-fired utility and industrial boilers represent less than seven percent of the total from these sources. As a result, only PART emissions from coal-fired boilers were examined in detail. For these coal-fired boilers, the PART emission factors can be classified in the general pulverized coal category and the more specific firing categories of stoker and cyclone. For each of these categories, the annual PART emissions can be calculated from the product of five factors: (1) coal usage rates, (2) average weight percent of ash in the coal, (3) ash factors, (4) average collector efficiencies, and (5) fraction of total plants using the collectors to control PART emissions. Data for each of these factors were obtained, respectively, from (1) the reference sources and analyses discussed in the previous sections plus Refs. 2-26 through 2-29 in the utility boiler area, (2) Ref. 2-25, (3) Ref. 2-11, (4) Ref. 2-25, and (5) Ref. 2-29 for utility boilers and Ref. 2-25 for industrial boilers. The values of percent ash, ash factors, collector efficiencies and control application [factors (2) through (5)] used to calculate 1967 to 1973 PART emissions in this analysis were as follows:

Boiler Type	Ash Factor[a]	% Ash	Collector Efficiency	Control Application	Net Control
Utility Boilers					
Pulverized	16	11.9	0.92	0.97	0.89
Stoker	13	11.2	0.80	0.87	0.70
Cyclone	3	11.8	0.91	0.79	0.72
Industrial Boilers					
Pulverized	16	10.6	0.85	0.95	0.81
Stoker	13	10.2	0.85	0.62	0.53
Cyclone	3	10.3	0.82	0.91	0.75

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[a] The ash factor multiplied by the percent of ash yields the uncontrolled emission factor.

For projections to 1980 in the utility boiler area, the assumption, based on data in Ref. 2-27, was that new construction would be 85 percent of the pulverized category, 15 percent of the cyclone firing type, and no new stoker construction. Application of control equipment to new construction was assumed to be 100 percent.

In the industrial boiler area, EPA standards of performance for new stationary sources (Ref. 2-30) require control efficiencies of about 0.988 (based on allowable emissions of 0.1 lb/million Btu and an average coal ash content of 10.4 percent), but these standards currently apply only to boilers with a capacity greater than 250 million Btu/hr heat input. It was assumed, therefore, that all new construction of boilers greater than 250 million Btu/hr capacity would be 100 percent controlled by the efficiency rate of 0.988. No regulations for industrial boilers of smaller capacity are currently forecast, and the control efficiencies and application (net control) therefore, were assumed to be the same in 1980 as in 1973.

Since PART emissions from gas- and oil-fired boilers, both utility and industrial, together represent a small fraction of those from coal-fired boilers, little effort was made to estimate changes in control efficiencies or control applications. Even on the assumption of 100 percent uncontrolled gas- and oil-fired utility and industrial boilers, the PART emissions from gas- and oil-firing projected to 1980 represent less than 7 percent of the projected total from these sources. PART emissions from gas- and oil-fired utility boilers were considered uncontrolled in all time periods. Controls for industrial boilers were treated the same except that new construction in the capacity range greater than 250 million Btu/hr were assumed to meet the EPA standards of performance for new stationary sources as given in Ref. 2-26.

2.5 NEDS DATA ANALYSIS

The NEDS data are stored in a large number of SCC by type of source (external combustion boiler, electric generation and industrial), by fuel (e.g., bituminous coal, lignite), and to some degree by firing types (e.g., pulverized wet, cyclone, stoker) (Table A.2 of Ref. 2-3). These data represent a more detailed breakdown than was available in the literature for the boilers of this study. The NEDS data also contain a large amount of detail on primary and secondary PART control equipment, categorized by control equipment identification codes (Table A.3 of Ref. 2-3), which does not appear to be available anywhere else. For these reasons, it was considered desirable to obtain a magnetic tape of data stored in the NEDS system for analysis. The availability of these in-house data on tape allowed extensive computer analysis and represents a powerful tool for emission inventories and other studies. A comparison of some of the totals, such as fuel usage and emissions, with data from other sources indicated that the NEDS data were considerably more comprehensive. In all cases, totals from various sources agreed as well as can be expected with the NEDS data. The NEDS data were initially accumulated and stored over the time period from about 1969 to 1972. Data available from other sources tend to represent time periods from about 1968 to 1973. Comparing the NEDS data with interpolated data for the same time period and considering the probable accuracies of these other sources, the NEDS data appear to be in good agreement.

Two significant problems with the NEDS tape data were found during this study. Significant errors of unknown origin can exist in some of the stored data. It appears that a single individual can submit data that are grossly in error and this error can enter into and remain in the NEDS data bank, undetected, grossly affecting all summary uses of the data. Annual CO emissions from coal-fired utility boilers were found to be more than a factor of five (more than 3×10^6 tons) too high. Two individuals submitting data in the process gas combustion area may have entered fuel usage data (total of several point sources within their plant) which were too high by factors of as much as 1000 (a total error of more than 2×10^{13} cu ft/yr). Such excessively high values can be detected with relative ease by screening the data for charge rates (fuel usage) larger than that of a very large plant. For excessively small values, however, Aerospace was unable to develop reliable, consistent methods for detecting errors or even to assure that zero values were not valid. The best overall checks found in this study involved correcting excessively high values and comparing the corrected totals against data from other sources, if available. These problems led to rather large estimates of the uncertainty of the final data.

The data stored in the NEDS were generated by many primary sources over a period of several years. In many cases, the emissions recorded were calculated from fuel usage rates and the then-current listing of emission factors. Most of the emission factors used in compiling the NEDS data are listed in the 1972 compilation (Ref. 2-31). From the 1972 compilation to the 1973 compilation (Ref. 2-11), there were some very large changes. Those important to this study are listed below:

Fuel	Plant Type	Emission	Emission Factor Ratio, 1973/1972
Coal	None	-	-
Oil	Utility	CO	75.0
	Industrial	CO	20.0
Natural Gas	Utility	NO_x	1.538
	Utility	HC	0.025
	Utility	CO	42.5
	Industrial	HC	0.075
	Industrial	CO	42.5

The changes in emission factors between these two compilations do not represent real changes in emissions but are more likely errors in the 1972 compilation, the first of its kind ever issued. In some cases, the emissions found in the NEDS tape data analyses could be brought into line with data from other sources by applying the above emission factor corrections. In the case of CO from all fuels, however, the emission totals from the NEDS tape analysis could not be brought into agreement with either the other sources in the literature or the NEDS nationwide emissions reports, even when these corrections were made.

Because of these problems, only the NEDS data which could be roughly verified by some other source were used. Similarly, because of the questions concerning the proper emission factors, the recorded NEDS emission data were not used as such. Instead, the NEDS fuel usage data were multiplied by 1973 emission factors obtained from Ref. 2-11. A check of resulting emissions totals calculated in this manner showed reasonably good agreement with direct NEDS emissions data, except as discussed in the CO and the process gas category.

A further complication in using the NEDS point source data (NEDS tape) results from the use of a number of fuels, concurrently or at different times, in the same facility. The emissions, operating times, PART control equipment, and compliance data (card nos. 3 through 5) are combined, listed, and stored as single values for the facility, while fuel and fuel usage data are listed separately by fuel (multiple cards no. 6). There appears to be no way to determine those emissions or fractions of operating time associated with each fuel. To generate total emissions data from the NEDS tape, this study utilized data from facilities using only one fuel (single card no. 6) to determine an effective emission factor for that SCC. Total emissions for that fuel were then calculated from the total usage of that fuel in that SCC. This procedure assumes that the emission factor for a given fuel in a given facility is the same whether or not the facility operates with multiple fuels. For example, there is some evidence in the literature that NO_x emissions during gas firing may be higher for a significant period of operation if it was preceded by a period of oil firing. No solution for this possible source of error was found.

One of the greatest values of the NEDS tape analysis is in the extremely detailed breakdown of PART control equipment usage and performance. No other source of such detail in the use of PART control equipment was identified. The data on the NEDS tape are such that further valuable information such as collector efficiencies, degree of application, and use of secondary collectors could also be developed. While such data were not of interest to the current study, it appears that a powerful tool for further data analysis is available.

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SECTION III

STATIONARY INTERNAL COMBUSTION ENGINES

3.1 INTRODUCTION

Stationary internal combustion (IC) engines include those used for (1) electrical power generation, (2) industrial use, (3) commercial and institutional application, and (4) engine testing. The fuels used in these engines range from natural gas to crude oil. The types of engines include diesel and spark ignition reciprocating engines and gas turbines.

Since by definition point source engines are those where one or more of the common emissions exceed 100 tons per year, it is to be expected that many stationary engines fall into the area source category (all stationary sources of pollution other than point sources). These engines fail to qualify as point source engines because of (1) a smallness in size, (2) a low usage rate, (3) a low emission factor, or (4) a combination of these factors.

Although the emissions total (point source plus area source) for most types of stationary engines is not much larger than point source only, four engine-fuel combinations were identified where area source emissions are estimated to be significantly large simply because their populations are enormous. These four engines are distillate-fueled and crude-oil-fueled turbines and gasoline-fueled and diesel-fueled reciprocating engines.

This study concentrates on point sources of air pollution as described in Section 3.3; Section 3.4 describes the assessment of the engine categories that make significant contributions to both area and point source emissions.

3.2 SUMMARY

The point source stationary IC engines studied along with their modified source classification code (MSCC) numbers and MSCC charge rate units are listed in Table 3-1. The 1975, 1980, 1976, and 1981 point source charge rates and emission rates are shown respectively, in Tables 3-2-a, 3-3-a, 3-4-a, and 3-5-a and their uncertainties in Tables 3-2-b, 3-3-b, 3-4-b, and 3-5-b.

Point source IC engines in 1980 will contribute about one-half million tons per year of nitrogen oxides (NO_x) and hydrocarbons (HC) and about 60,000 tons of carbon monoxide (CO) annually. The annual area source emissions for the four previously mentioned engines are estimated to be about 3 million tons of NO_x, 1 million tons of HC, and about 13.5 million tons of CO. The largest contributor to stationary IC engine pollution is the conventional gasoline engine.

3.3 POINT SOURCES

This category includes fixed installations of diesel and spark ignition reciprocating engines and gas turbine engines. These engines are used for electrical power generation and for industrial use such as pumps for fuels, water, and sewage and compressors for gaseous fuels and air. The three basic types of engines may be further subdivided into subtypes such as two and four stroke, direct and indirect injection, and carburetion.

However, obtaining emissions from such breakdowns is frustrated by a lack of a breakdown in annual fuel consumption and emission factors by engine subtype. Thus, it is not possible to establish the effect on the environment of variations in engine configuration, state of repair, or specific application. Significant pollution contributors in this category are listed in Table 3-1.

3.3.1 Diesel Engines

Diesel engines are used for electrical generation in oil and gas pipelines, oil and gas exploration, and pumping water and sewage.

(Continued on page 3-16)

Table 3-1. DEFINITION OF INTERNAL COMBUSTION PROCESSES

MSCC	Source Category	Charge Rate Unit
201000000	Internal Combustion (Electrical Generating)	
201001010	Distillate-oil-fueled turbine	1000 gal/yr
201002010	Natural-gas-fueled turbine	Million cu ft/yr
201002020	Natural-gas-fueled reciprocating	Million cu ft/yr
201003010	Diesel-fueled reciprocating	1000 gal/yr
201999970	Other, not classified	Million cu ft/yr
201999980	Other (not classified)	1000 gal/yr
202000000	Internal Combustion (Industrial)	
202001010	Distillate-oil-fueled turbine	1000 gal/yr
202002010	Natural gas turbine	Million cu ft/yr
202002020	Natural gas reciprocating	Million cu ft/yr
202003010	Gasoline reciprocating	1000 gal/yr
202004010	Diesel reciprocating	1000 gal/yr
202999970	Other (not classified)	Million cu ft/yr

Table 3-2-a. 1975 INTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

INTERNAL COMBUSTION ENGINES PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
201001000	1088100.	.120	.002	.010	.008
201001010	1088100.	.120	.002	.010	.008
201002000	338860.	.096	.001	.000	.000
201002010	115840.	.020	.001	.000	.000
201002020	223020.	.076	0.000	0.000	0.000
201003000	75159.	.011	.001	.005	.002
201003010	75159.	.011	.001	.005	.002
201999000		.017	.083	.002	.001
201999970	7258.	.011	.012	0.000	0.000
201999980	115600.	.006	.072	.002	.001
202001000	65953.	.004	.000	.002	.001
202001010	65953.	.004	.000	.002	.001
202002000	973960.	.348	.089	.044	.004
202002010	69322.	.011	.003	.003	.000
202002020	904640.	.337	.086	.041	.004
202003000	3470.	.000	.000	.003	.000
202003010	3470.	.000	.000	.003	.000
202004000	26201.	.005	.000	.002	.000
202004010	26201.	.005	.000	.002	.000
202999000	23828.	.003	.172	.001	.000
202999970	23828.	.003	.172	.001	.000

Table 3-2-b. 1975 INTERNAL COMBUSTION UNCERTAINTIES

INTERNAL COMBUSTION ENGINES PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)							
				NOX		HC		CO		PART
201001000	+	3320600.	+	.369	+	.005	+	.029	+	.024
	-	1088100.	-	.120	-	.002	-	.010	-	.008
201001010	+	3320600.	+	.369	+	.005	+	.029	+	.024
	-	1088100.	-	.120	-	.002	-	.010	-	.008
201002000	+	417670.	+	.072	+	.002	+	.003	+	.001
	-	118200.	-	.022	-	.001	-	.000	-	.000
201002010	+	417010.	+	.072	+	.002	+	.003	+	.001
	-	115840.	-	.020	-	.001	-	.000	-	.000
201002020	+	23532.	+	.008	+	0.000	+	0.000	+	0.000
	-	23532.	-	.008	-	0.000	-	0.000	-	0.000
201003000	+	14799.	+	.003	+	.000	+	.002	+	.001
	-	14799.	-	.002	-	.000	-	.001	-	.001
201003010	+	14799.	+	.003	+	.000	+	.002	+	.001
	-	14799.	-	.002	-	.000	-	.001	-	.001
201999000			+	.003	+	.012	+	.000	+	.001
			-	.003	-	.012	-	.000	-	.001
201999970	+	1804.	+	.003	+	.003	+	0.000	+	0.000
	-	1804.	-	.003	-	.003	-	0.000	-	0.000
201999980	+	18027.	+	.001	+	.011	+	.000	+	.001
	-	18027.	-	.001	-	.011	-	.000	-	.001
202001000	+	22224.	+	.001	+	.000	+	.001	+	.000
	-	22224.	-	.001	-	.000	-	.001	-	.000
202001010	+	22224.	+	.001	+	.000	+	.001	+	.000
	-	22224.	-	.001	-	.000	-	.001	-	.000
202002000	+	616740.	+	.111	+	.030	+	.024	+	.005
	-	174900.	-	.061	-	.016	-	.008	-	.004

Table 3-2-b.   1975 INTERNAL COMBUSTION UNCERTAINTIES

```
                          INTERNAL COMBUSTION ENGINES                  PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975      RUN DATE= MAR 22,1977
  MODIFIED        TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC        (SCC UNITS)       NOX            HC             CO           PART

201001000   +    3320600.    +  .369     +  .005      +  .029     +  .024
            -    1088100.    -  .120     -  .002      -  .010     -  .008

201001010   +    3320600.    +  .369     +  .005      +  .029     +  .024
            -    1088100.    -  .120     -  .002      -  .010     -  .008

201002000   +     417670.    +  .072     +  .002      +  .003     +  .001
            -     118200.    -  .022     -  .001      -  .000     -  .000

201002010   +     417010.    +  .072     +  .002      +  .003     +  .001
            -     115840.    -  .020     -  .001      -  .000     -  .000
201002020   +      23532.    +  .008     + 0.000      + 0.000     + 0.000
            -      23532.    -  .008     - 0.000      - 0.000     - 0.000

201003000   +      14799.    +  .003     +  .000      +  .002     +  .001
            -      14799.    -  .002     -  .000      -  .001     -  .001

201003010   +      14799.    +  .003     +  .000      +  .002     +  .001
            -      14799.    -  .002     -  .000      -  .001     -  .001

201999000                    +  .003     +  .012      +  .000     +  .001
                             -  .003     -  .012      -  .000     -  .001

201999970   +       1804.    +  .003     +  .003      + 0.000     + 0.000
            -       1804.    -  .003     -  .003      - 0.000     - 0.000
201999980   +      18027.    +  .001     +  .011      +  .000     +  .001
            -      18027.    -  .001     -  .011      -  .000     -  .001

202001000   +      22224.    +  .001     +  .000      +  .001     +  .000
            -      22224.    -  .001     -  .000      -  .001     -  .000

202001010   +      22224.    +  .001     +  .000      +  .001     +  .000
            -      22224.    -  .001     -  .000      -  .001     -  .000

202002000   +     616740.    +  .111     +  .030      +  .024     +  .005
            -     174900.    -  .061     -  .016      -  .008     -  .004
```

Table 3-2-b. 1975 INTERNAL COMBUSTION UNCERTAINTIES (Continued)

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                              INTERNAL COMBUSTION ENGINES                       PAGE  2
 TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975          RUN DATE= MAR 22,1977
                                           EMISSIONS (MILLIONS OF TONS / YEAR)
  MODIFIED          TACRP                                 HC           CO           PART
    SCC          (SCC UNITS)          NOX
  202002010    +     595470.       + .094        + .024       + .022       + .004
               -      69322.       - .011        - .003       - .003       - .000
  202002020    +     160580.       + .060        + .018       + .008       + .004
               -     160580.       - .060        - .015       - .007       - .004

  202003000    +       1172.       + .000        + .000       + .002       + .000
               -       1172.       - .000        - .000       - .001       - .000

  202003010    +       1172.       + .000        + .000       + .002       + .000
               -       1172.       - .000        - .000       - .001       - .000

  202004000    +      26055.       + .005        + .000       + .002       + .000
               -      26055.       - .005        - .000       - .002       - .000

  202004010    +      26055.       + .005        + .000       + .002       + .000
               -      26055.       - .005        - .000       - .002       - .000

  202999000    +       5925.       + .001        + .175       + .000       + .000
               -       5925.       - .001        - .043       - .000       - .000

  202999970    +       5925.       + .001        + .175       + .000       + .000
               -       5925.       - .001        - .043       - .000       - .000
```

Table 3-3-a. 1980 INTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

INTERNAL COMBUSTION ENGINES PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	NOX	HC	CO	PART
		EMISSIONS (MILLIONS OF TONS / YEAR)			
201001000	1275600.	.141	.002	.011	.009
201001010	1275600.	.141	.002	.011	.009
201002000	290630.	.083	.000	.000	.000
201002010	98582.	.017	.000	.000	.000
201002020	192050.	.066	0.000	0.000	0.000
201003000	82909.	.012	.001	.005	.002
201003010	82909.	.012	.001	.005	.002
201999000		.019	.100	.002	.002
201999970	8089.	.012	.013	0.000	0.000
201999980	140600.	.007	.087	.002	.002
202001000	79753.	.005	.000	.002	.001
202001010	79753.	.005	.000	.002	.001
202002000	824330.	.297	.076	.037	.004
202002010	48187.	.008	.002	.002	.000
202002020	776140.	.289	.074	.035	.003
202003000	4627.	.001	.001	.004	.000
202003010	4627.	.001	.001	.004	.000
202004000	35626.	.006	.000	.003	.000
202004010	35626.	.006	.000	.003	.000
202999000	32923.	.005	.237	.001	.000
202999970	32923.	.005	.237	.001	.000

Table 3-3-b. 1980 INTERNAL COMBUSTION UNCERTAINTIES

```
                         INTERNAL COMBUSTION ENGINES                          PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980         RUN DATE= MAR 22,1977
MODIFIED             TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC             (SCC UNITS)          NOX          HC           CO          PART
201001000     +     3472000.       +  .387     +  .005     +  .030     +  .025
              -     1275600.       -  .141     -  .002     -  .011     -  .009

201001010     +     3472000.       +  .387     +  .005     +  .030     +  .025
              -     1275600.       -  .141     -  .002     -  .011     -  .009

201002000     +      419680.       +  .074     +  .002     +  .003     +  .001
              -      109070.       -  .023     -  .000     -  .000     -  .000

201002010     +      417070.       +  .072     +  .002     +  .003     +  .001
              -       98582.       -  .017     -  .000     -  .000     -  .000
201002020     +       46677.       +  .016     + 0.000     + 0.000     + 0.000
              -       46677.       -  .016     - 0.000     - 0.000     - 0.000

201003000     +       18635.       +  .003     +  .000     +  .002     +  .001
              -       18635.       -  .003     -  .000     -  .001     -  .001

201003010     +       18635.       +  .003     +  .000     +  .002     +  .001
              -       18635.       -  .003     -  .000     -  .001     -  .001

201999000                          +  .005     +  .026     +  .001     +  .001
                                   -  .005     -  .026     -  .001     -  .001

201999970     +        3163.       +  .005     +  .005     + 0.000     + 0.000
              -        3163.       -  .005     -  .005     - 0.000     - 0.000
201999980     +       41231.       +  .002     +  .026     +  .001     +  .001
              -       41231.       -  .002     -  .026     -  .001     -  .001

202001000     +       49437.       +  .003     +  .000     +  .001     +  .001
              -       49437.       -  .003     -  .000     -  .001     -  .001

202001010     +       49437.       +  .003     +  .000     +  .001     +  .001
              -       49437.       -  .003     -  .000     -  .001     -  .001

202002000     +      662170.       +  .139     +  .037     +  .026     +  .005
              -      276270.       -  .1C2     -  .026     -  .013     -  .003
```

Table 3-3-b. 1980 INTERNAL COMBUSTION UNCERTAINTIES (Continued)

INTERNAL COMBUSTION ENGINES

PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980

RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		EMISSIONS (MILLIONS OF TONS / YEAR)						
				NOX		HC		CO		PART
202002010	+	603710.	+	.095	+	.025	+	.022	+	.004
	-	48187.	-	.008	-	.002	-	.005	-	.000
202002020	+	272030.	+	.101	+	.027	+	.013	+	.003
	-	272030.	-	.101	-	.026	-	.012	-	.003
202003000	+	2311.	+	.000	+	.000	+	.003	+	.000
	-	2311.	-	.000	-	.000	-	.002	-	.000
202003010	+	2311.	+	.000	+	.000	+	.003	+	.000
	-	2311.	-	.000	-	.000	-	.002	-	.000
202004000	+	26452.	+	.005	+	.000	+	.002	+	.000
	-	26452.	-	.005	-	.000	-	.002	-	.000
202004010	+	26452.	+	.005	+	.000	+	.002	+	.000
	-	26452.	-	.005	-	.000	-	.002	-	.000
202999000	+	14845.	+	.002	+	.258	+	.001	+	.000
	-	14845.	-	.002	-	.107	-	.001	-	.000
202999970	+	14845.	+	.002	+	.258	+	.001	+	.000
	-	14845.	-	.002	-	.107	-	.001	-	.000

Table 3-4-a. 1976 INTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

INTERNAL COMBUSTION ENGINES PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
201001000	1125600.	.124	.002	.010	.008
201001010	1125600.	.124	.002	.010	.008
201002000	329210.	.094	.001	.000	.000
201002010	112390.	.019	.001	.000	.000
201002020	216830.	.074	0.000	0.000	0.000
201003000	76709.	.011	.001	.005	.002
201003010	76709.	.011	.001	.005	.002
201999000		.017	.087	.002	.001
201999970	7424.	.011	.012	0.000	0.000
201999980	120600.	.006	.075	.002	.001
202001000	68713.	.004	.000	.002	.001
202001010	68713.	.004	.000	.002	.001
202002000	944040.	.338	.086	.043	.004
202002010	65095.	.010	.003	.002	.000
202002020	878940.	.327	.083	.040	.004
202003000	3702.	.000	.000	.003	.000
202003010	3702.	.000	.000	.003	.000
202004000	28086.	.005	.000	.002	.000
202004010	28086.	.005	.000	.002	.000
202999000	25647.	.004	.185	.001	.000
202999970	25647.	.004	.185	.001	.000

Table 3-4-b. 1976 INTERNAL COMBUSTION UNCERTAINTIES

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                                                                                PAGE  1
                                INTERNAL COMBUSTION ENGINES
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976            RUN DATE= MAR 22,1977
                                          EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED          TACRP                NOX            HC             CO            PART
  SCC          (SCC UNITS)
                                                  +  .005         +  .029       +  .024
201001000   +   3339400.         +  .372          -  .002         -  .010       -  .008
            -   1125600.         -  .124

201001010   +   3339400.         +  .372          +  .005         +  .029       +  .024
            -   1125600.         -  .124          -  .002         -  .010       -  .008

                                                  +  .002         +  .003       +  .001
201002000   +    417950.         +  .072          -  .001         -  .000       -  .000
            -    115800.         -  .022
                                                                  +  .003       +  .001
                 417020.         +  .072          +  .002         -  .000       -  .000
201002010   +    112390.         -  .019          -  .001         + 0.000       + 0.000
            -     27906.         +  .010          + 0.000         - 0.000       - 0.000
201002020   +     27906.         -  .010          - 0.000
            -
                                                  +  .000         +  .002       +  .001
201003000   +     15352.         +  .003          -  .000         -  .001       -  .001
            -     15352.         -  .002

201003010   +     15352.         +  .003          +  .000         +  .002       +  .001
            -     15352.         -  .002          -  .000         -  .001       -  .001

                                                  +  .014         +  .000       +  .001
201999000                        +  .003          -  .014         -  .000       -  .001
                                 -  .003
                                                  +  .003         + 0.000       + 0.000
201999970   +      2041.         +  .003          -  .003         - 0.000       - 0.000
            -      2041.         -  .003          +  .014         +  .000       +  .001
201999980   +     22360.         +  .001          -  .014         -  .000       -  .001
            -     22360.         -  .001
                                                                  +  .001       +  .000
202001000   +     27605.         +  .002          +  .000         -  .001       -  .000
            -     27605.         -  .002          -  .000
                                                                  +  .001       +  .000
202001010   +     27605.         +  .002          +  .000         -  .001       -  .000
            -     27605.         -  .002          -  .000
                                                                  +  .024       +  .005
202002000   +    623450.         +  .116          +  .031         -  .009       -  .004
            -    192420.         -  .060          -  .017
```

Table 3-4-b. 1976 INTERNAL COMBUSTION UNCERTAINTIES (Continued)

```
                              INTERNAL COMBUSTION ENGINES                               PAGE  2
 TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976              RUN DATE= MAR 22,1977
  MODIFIED          TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC         (SCC UNITS)        NOX             HC              CO              PART
  202002010   +      596580.    +  .094      +  .024      +  .022      +  .004
              -       65095.    -  .010      -  .003      -  .002      -  .000
  202002020   +      181070.    +  .068      +  .019      +  .009      +  .004
              -      181070.    -  .067      -  .017      -  .008      -  .004

  202003000   +        1399.    +  .000      +  .000      +  .002      +  .000
              -        1399.    -  .000      -  .000      -  .001      -  .000

  202003010   +        1399.    +  .000      +  .003      +  .002      +  .000
              -        1399.    -  .000      -  .000      -  .001      -  .000

  202004000   +       26110.    +  .005      +  .000      +  .002      +  .000
              -       26110.    -  .005      -  .000      -  .002      -  .000

  202004010   +       26110.    +  .005      +  .000      +  .002      +  .000
              -       26110.    -  .005      -  .000      -  .002      -  .000

  202999000   +        7676.    +  .001      +  .191      +  .000      +  .000
              -        7676.    -  .001      -  .055      -  .000      -  .000

  202999970   +        7676.    +  .001      +  .191      +  .000      +  .000
              -        7676.    -  .001      -  .055      -  .000      -  .000
```

Table 3-4-b. 1976 INTERNAL COMBUSTION UNCERTAINTIES (Continued)

INTERNAL COMBUSTION ENGINES PAGE 2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACR (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
202002010	+	36500.	+ .031	+ .023	+ .032	+ .004
	-	36500.	- .030	- .023	- .004	- .000
202002020	+	161070.	+ .068	+ .019	+ .005	+ .004
	-	161070.	- .067	- .017	- .004	- .004
202003000	+	1399.	+ .000	+ .000	+ .002	+ .000
	-	1399.	- .000	- .000	- .001	- .000
202003010	+	1399.	+ .000	+ .003	+ .002	+ .000
	-	1399.	- .000	- .000	- .001	- .000
202004000	+	26110.	+ .005	+ .000	+ .002	+ .000
	-	26110.	- .005	- .000	- .002	- .000
202004010	+	26110.	+ .005	+ .000	+ .002	+ .000
	-	26110.	- .005	- .000	- .002	- .000
202999000	+	7676.	+ .001	+ .131	+ .000	+ .000
	-	7676.	- .001	- .033	- .000	- .000
202999070	+	7676.	+ .001	+ .131	+ .000	+ .000
	-	7676.	- .001	- .033	- .000	- .000

Table 3-5-a. 1981 INTERNAL COMBUSTION EMISSIONS AND CHARGE RATES

PAGE 1

INTERNAL COMBUSTION ENGINES

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	NOX	EMISSIONS (MILLIONS OF TONS / YEAR) HC	CO	PART
201001000	1313100.	.145	.002	.012	.009
201001010	1313100.	.145	.002	.012	.009
201002000	280980.	.080	.000	.000	.000
201002010	95131.	.016	.000	.000	.000
201002020	185850.	.064	0.000	0.000	0.000
201003000	84459.	.012	.001	.005	.002
201003010	84459.	.012	.001	.005	.002
201999000		.020	.104	.002	.002
201999970	8255.	.012	.013	0.000	0.000
201999980	145600.	.007	.096	.304	.052
202001000	82513.	.005	.000	.002	.001
202001010	82513.	.005	.000	.002	.001
202002000	794400.	.286	.073	.036	.003
202002010	43960.	.007	.002	.002	.000
202002020	750440.	.280	.071	.034	.003
202003000	4859.	.001	.001	.004	.000
202003010	4859.	.001	.001	.004	.000
202004000	37511.	.007	.001	.003	.000
202004010	37511.	.007	.001	.003	.000
202999000	34742.	.005	.250	.001	.000
202999970	34742.	.005	.250	.001	.000

Table 3-5-b. 1981 INTERNAL COMBUSTION UNCERTAINTIES

INTERNAL COMBUSTION ENGINES PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		NOX		HC		CO		PART
				EMISSIONS (MILLIONS OF TONS / YEAR)						
201001000	+	3510700.	+	.192	+	.003	+	.031	+	.026
	-	1313100.	-	.143	-	.002	-	.012	-	.009
201001010	+	3510700.	+	.192	+	.003	+	.031	+	.026
	-	1313100.	-	.143	-	.002	-	.012	-	.009
201002000	+	420260.	+	.074	+	.002	+	.003	+	.001
	-	108180.	-	.024	-	.000	-	.000	-	.000
201002010	+	417090.	+	.072	+	.002	+	.003	+	.001
	-	95131.	-	.016	-	.000	-	.000	-	.000
201002020	+	51514.	+	.018	+	0.000	+	0.000	+	0.000
	-	51514.	-	.018	-	0.000	-	0.000	-	0.000
201003000	+	19638.	+	.003	+	.000	+	.002	+	.001
	-	19638.	-	.003	-	.000	-	.001	-	.001
201003010	+	19638.	+	.003	+	.000	+	.002	+	.001
	-	19638.	-	.003	-	.000	-	.001	-	.001
201999000			+	.006	+	.029	+	.001	+	.002
			-	.006	-	.029	-	.001	-	.002
201999970	+	3463.	+	.005	+	.006	+	0.000	+	0.000
	-	3463.	-	.005	-	.006	-	0.000	-	0.000
201999980	+	46097.	+	.002	+	.029	+	.001	+	.002
	-	46097.	-	.002	-	.029	-	.001	-	.002
202001000	+	34926.	+	.003	+	.000	+	.001	+	.001
	-	34926.	-	.003	-	.000	-	.001	-	.001
202001010	+	34926.	+	.003	+	.000	+	.001	+	.001
	-	34926.	-	.003	-	.000	-	.001	-	.001
202002000	+	674550.	+	.146	+	.038	+	.027	+	.005
	-	299230.	-	.110	-	.028	-	.014	-	.003

Table 3-5-b. 1981 INTERNAL COMBUSTION UNCERTAINTIES (Continued)

INTERNAL COMBUSTION ENGINES PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)		NOX		HC		CO		PART
				EMISSIONS (MILLIONS OF TONS / YEAR)						
202002010	+	606150.	+	.096	+	.025	+	.023	+	.004
	-	43960.	-	.007	-	.002	-	.002	-	.000
202002020	+	295990.	+	.110	+	.029	+	.014	+	.003
	-	295990.	-	.110	-	.020	-	.014	-	.003
202003000	+	2540.	+	.000	+	.000	+	.003	+	.000
	-	2540.	-	.000	-	.000	-	.002	-	.000
202003010	+	2540.	+	.000	+	.000	+	.003	+	.000
	-	2540.	-	.000	-	.000	-	.002	-	.000
202004000	+	26568.	+	.005	+	.000	+	.002	+	.000
	-	26568.	-	.005	-	.000	-	.002	-	.000
202004010	+	26568.	+	.005	+	.000	+	.002	+	.000
	-	26568.	-	.005	-	.000	-	.002	-	.000
202999000	+	16652.	+	.002	+	.275	+	.001	+	.000
	-	16652.	-	.002	-	.120	-	.001	-	.000
202999970	+	16652.	+	.002	+	.275	+	.001	+	.000
	-	16652.	-	.002	-	.120	-	.001	-	.000

For electrical generation, diesel engines represent on the order of 1.2 percent of the 1970 total electrical generating capacity in the United States and only about 0.3 percent of the total power generated, for an average utilization of about 12 percent. These engines are used for electrical peaking power and also standby installation. The projected utilization factor for 1980 drops to eight percent.

Diesel engines represent about four percent of the installed horsepower in pipelines and about five percent of the power generated. For oil and gas exploration, about 75 percent of the power used is generated by diesel engines. For municipal water and sewage pumping about 50 percent is diesel-powered, while agricultural water pumping is done almost exclusively by diesel engines.

3.3.2 Gas Turbines

The main applications for stationary gas turbines include electric power generation for utilities and for industrial and pipeline use. Gas turbines have low initial costs, short delivery times, small space requirements, flexible fuel needs, and high thermal efficiency. For these reasons, turbines are being installed in electrical plants to replace steam plants or to add capacity.

Gas turbine engines vary greatly in size and configuration. Turbines have single- or two-shaft designs. Both types can be operated in simple cycles, regenerative cycles, or combined cycles. The simple-cycle engines operate at 25 to 30 percent efficiency. Regenerative cycles utilize a heat exchanger which uses turbine exhaust gases to heat the air as it passes from the compressor into the combustor. Efficiency of these engines runs about 34 to 38 percent. In the combined cycle, turbine exhaust gas is used to generate steam which drives a second generator or other device. Efficiencies of 40 to 42 percent are realized with these units.

3.3.3 Spark Ignition Engines

The spark ignition internal combustion engine is the most widely used powerplant in the world today. These engines range from small single-cylinder units producing as little as a fraction of a horsepower to large multicylinder units with power ratings of several thousand horsepower. The large units are predominantly used in stationary power applications.

Medium-sized gasoline engines (50 to 200 hp) are used for commercial and construction site compressors, pumps, blowers, and electric power generators. Medium-large spark ignition engines (200 to 1000 hp) are generally operated on gaseous fuels to power gas compressors or standby power generators. Large spark ignition engines (greater than 1000 hp) always operate on gaseous fuels and are used for gas-well recompression, gas plant compressors, refinery process compressors, water and sewage pumping, and continuous electrical power generation.

3.3.4 Charge Rate

The NEDS was used as the primary source of data. Annual charge rates (fuel consumption), as of the year of record, formed the starting point for the charge rate projections.

The rate of change of charge rate for electric utility turbines is based on the fuel demand data shown in Figure 3-1. The total rises every year for all fuels except natural gas, reflecting the increased dependence on turbine power. Lacking fuel consumption projections on gas turbines for industrial use, the assumption was made that charge rate trends for these turbines are equal to those for electrical power demand. For turbines used in the handling of petroleum products in such services as pumping and pressurization, it is also reasonable to assume that the same trends exist as for the electric utility consumers.

For reciprocating engines, it was necessary to use less direct methods of estimating charge rate changes. Table 3-6 shows data on the number of IC engines versus end use for gasoline and diesel fuels. Only those listed in the source (Ref. 3-4) for construction, generator sets, or general industrial use were considered in this part of the study. Of the engines produced (Table 3-6), many were probably for replacement of

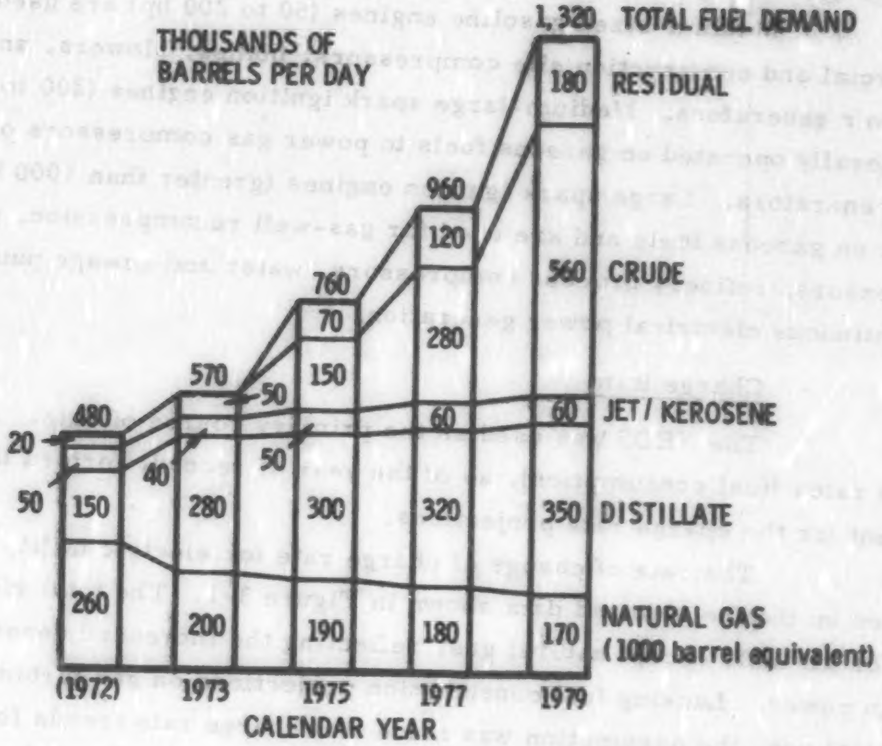

Figure 3-1. Electric utility gas turbine fuel demand

Table 3-6. INTERNAL COMBUSTION ENGINE DISTRIBUTION: NUMBER VERSUS END USE

Engine Type and End Use[a]	Number of IC Engines Distributed[b]									
	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Gasoline										
Construction and General Industrial Use	1,172,836	1,306,153	1,192,112	1,239,276	1,424,790	1,225,742	1,174,173	975,637	1,399,800	1,272,551
Generator Sets	67,769	76,678	67,930	67,798	90,760	86,264	104,142	146,270	165,183	176,014
Total Gasoline	1,240,605	1,382,831	1,260,042	1,307,074	1,515,550	1,312,006	1,278,320	1,121,907	1,564,983	1,448,565
Diesel										
Construction and General Industrial Use	130,185	140,021	134,665	139,577	156,329	142,266	130,216	150,823	175,071	200,054
Generator Sets	13,209	12,746	5,564	6,070	8,535	10,201	8,400	9,661	13,327	15,212
Total Diesel	143,394	152,767	140,299	145,647	164,864	152,467	138,616	160,484	188,398	215,266
Total IC Engines	1,383,999	1,535,598	1,400,271	1,452,721	1,680,414	1,464,473	1,416,936	1,282,991	1,753,381	1,663,831

[a] Ref. 3-4.

[b] Represents total number of engines shipped or produced and incorporated into products at the same establishment during the time period 1965 through 1974.

worn-out engines or were exported, with perhaps only 10 percent of production going into new installations. Hence, the assumption of a change of charge rate based on 10 percent of the annual production seems conservative, but the uncertainty of this slope is rather large. Comparison of several sources of predicted consumption for electrical generation shows variations in slopes of from 3 to 22 percent per year. Thus, a 10 percent slope with 10 percent uncertainty in the slope was assumed.

3.3.5 Emission Factors

The emission factors were derived from the NEDS data by dividing the emissions by the charge rate. Other sources of emission factors (Refs. 3-1 through 3-3) were used to determine the uncertainty of the NEDS data. It was assumed that emission factors would not change with the passage of time. The only factor that would change that assumption would be the imposition of clean air standards on all of the users of this equipment. This factor was ignored in the data input; thus, the data represent emissions with no controls imposed.

3.3.6 Results

Table 3-3-a shows the 1980 projections of annual charge rates and emissions for point sources. The data show that about one-half million tons per year of NO_x and HC are produced by stationary IC engines. Of this amount, about 50 percent of the NO_x and 20 percent of the HC are from electrical generating plants, with the remainder from industrial sources. In the electrical generating category, the worst offender is the distillate-fueled gas turbine. With a charge rate of over 1.25 billion gal/year, it contributes about 140,000 tons/year of NO_x. In the industrial use classification, natural gas reciprocating engines contribute about 300,000 tons/year of NO_x from about 780 billion cu ft/year of gas. The uncertainty in 1980 charge rates and emissions are shown in Table 3-3-b.

3.4 TOTAL EMISSIONS FROM SELECTED STATIONARY IC ENGINES (POINT AND AREA SOURCES)

3.4.1 Introduction

As reported in Section 3.1, four stationary IC engine-fuel combinations were identified whose total (area plus point source) emissions far exceed the estimated point source emissions reported in Section 3.3. The four offenders are distillate-fueled and crude-oil-fueled turbines, and gasoline-fueled and diesel-fueled reciprocating engines. Identification of the engine types responsible for these large area source emissions was possible through analysis of the data extracted from Refs. 3-1, 3-4, and 3-5. This section reports the rationale and results of estimating the total emissions for those four types of engines.

3.4.2 Summary

Four engine-fuel combinations were found to contribute potentially significant amounts of area source pollution: distillate-fueled and crude-oil-fueled turbines and gasoline-based and diesel-fueled reciprocating engines. Table 3-7 shows the total emissions for these engines in 1980. Table 3-8 gives the 1980 projection of pollutants from these four sources in excess of the point sources data reported in Section 3.3.

3.4.3 Discussion

3.4.3.1 Turbines

In 1971, the installed horsepower for gas turbines was about 38 million. About 29 million of that was for electrical power generation, and the remainder was for pipelines and natural gas processing. For power generation, gas turbines provide the repowering when old and less efficient plants are retired and also fill the need for increased power. In 1970, approximately 5 percent of the power generated was by gas turbines; by 1980, it is estimated that as much as 12 percent of the power capacity will be from gas turbines. Projected electrical generation use is about 120-million hp in

Table 3-7. 1980 PROJECTION OF TOTAL INTERNAL COMBUSTION ENGINE EMISSIONS[a]

Source Category	Emissions, million tons/yr			Charge Rate, 1000 gal/yr
	NO_x	HC	CO	
Distillate-Fueled Turbines	0.459	0.011	0.060	6.70×10^6
Crude-Oil-Fueled Turbines	0.884	0.022	0.116	12.90×10^6
Gasoline-Fueled Reciprocating Engines	1.345	0.924	13,273	12.75×10^6
Diesel-Fueled Reciprocating Engines	0.432	0.032	0.142	2.40×10^6
Total	3.120	0.989	13.591	34.75×10^6

[a] Point source and area source emissions.

Table 3-8. 1980 PROJECTION OF AREA SOURCE INTERNAL COMBUSTION ENGINE EMISSIONS

Source Category	Emissions, million tons/yr			Charge Rate, 1000 gal/yr
	NO_x	HC	CO	
Distillate-Fueled Turbines	0.313	0.009	0.047	5.34×10^6
Crude-Oil-Fueled Turbines	0.884	0.022	0.116	12.90×10^6
Gasoline-Fueled Reciprocating Engines	1.344	0.923	13.269	12.74×10^6
Diesel-Fueled Reciprocating Engines	0.414	0.031	0.134	2.28×10^6
Total	2.955	0.985	13.566	33.26×10^6

1980. Similar growth rates for other uses can be expected By 1980, therefore, total gas turbine installed horsepower will be on the order of 150 million.

Figure 3-1 shows distillate consumption for gas turbines for electrical generation growing to 350,000 bbl (14.7-million gal/day in 1979). Projecting this to 1980, fuel consumption can be expected to be 5.6-billion gal/year for electrical generation alone. Adding consumption for other uses increases this number by 20 percent to 6.7-billion gal/year. The 1979 crude oil demand from Figure 3-1 is 560,000 bbl (23.52-million gal/day). Projecting the growth rate to 1980 and adding 20 percent for uses other than electrical generation, the estimated consumption of crude oil in gas turbines will be 12.9-billion gal/year in 1980.

Emission factors used to estimate total emissions are the average of emission factors derived from the NEDS data and from Refs. 3-1 through 3-3. Crude oil emission factors were assumed to be the same as the distillate emission factors, in the absence of any other information.

3.4.3.2 Diesel Engines

In Ref. 3-1, the total estimated installed horsepower of stationary diesel engines was about 16-million bhp (brake horsepower) in 1971. Of this total, 5.2-million bhp were used for electrical generation, and the remainder was for industrial uses.

Table 3-6 indicates that about 215,000 diesel engines for industrial construction and generator sets were shipped in 1974. Total horsepower was about 42 million for engines of greater than 50 hp. To estimate fuel consumption, it was necessary to make the following assumptions:

a. Twenty percent of the engines shipped were new installations. The remainder were replacement engines or were exported (nine percent were exported in 1974).

b. Engines will be operated on an average of 1170 hr/year. NEDS data for 1970 indicate an average of 1888 hr/year for electrical generation and 5282 hr/year for industrial use. The estimated 1980 operation is 8 percent for electrical generation and 15 percent for industrial use.

c. Specific fuel consumption is 0.40 lb/bhp-hr. (According to Ref. 3-1, an average specific fuel consumption is 0.403 for diesels of this class.) Using data from Ref. 3-4 and the 1974 growth rate, it is estimated that diesel horsepower will be about 36 million in 1980; fuel consumption will be 2.40-billion gal/year (7.0 lb/gal). Emission factors were derived as for gas turbines (Section 3.3.5).

3.4.3.3 Spark Ignition Engines

Spark ignition engines, both liquid- and gaseous-fueled, are by two orders of magnitude the most common engines in the country today. The 1971 total installed horsepower is estimated at 800-million (Ref. 3-1). These engines are used for everything from small power tools to 1000-hp and greater compressors, pumps, and electrical power installations.

Table 3-6 shows the number of IC engines shipped in the years 1965 to 1974. Gasoline engines for construction, general industrial use, and electrical generator sets number well over one million in each of those years. Assuming that the engines in these categories are the larger horsepower rated engines, this represents about 50-million hp/year. Of the 800-million hp in 1971, it is estimated that about 50 percent was devoted to these categories.

Using the same assumptions as were made for diesel engines, namely, that 20 percent were new installations, but now assuming the average engine is used for 300 hr/year, the 1980 estimated installed horsepower is 490 million and the annual fuel consumption (at 0.52 lb/bhp-hr) is 12.75-billion-gal/year. Gasoline density of 6.0 lb/gal was used in this computation.

Emission factors were derived by the same method used for gas turbines (Section 3.3.5).

3.4.3.4 Results and Conclusions

From charge rates and emission factors, the 1980 total emissions were estimated and are presented in Table 3-7. The data indicate that about 3-million tons of NO_x, 1-million tons of HC, and 13.6-million tons of CO (mainly from gasoline engines) will be emitted from these engines. Table 3-8 is the same data minus the point source data in Table 3-3-a. This shows an estimate of the area source pollution.

The uncertainty of the data is large. Although the assumptions made are thought to be conservative, the real contribution of these engines could be much higher.

The conclusions to be drawn from this study are that a large number of stationary IC engines are being produced in this country every year and that information as to the application and utilization rates of these engines is lacking. Therefore, a potentially large source of air pollution is going undetected. Efforts to trace these engines to the user and to estimate numbers of engines, use rate, and emissions are recommended.

3.5 REFERENCES

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3-2. C. R. McGowin, Stationary Internal Combustion Engines in the United States, EPA-R2-73-210, Shell Development Company, Houston, Texas (April 1973).

3-3. NEDS Source Classification Codes and Emission Factor Listing (SCC Listing), Office of Air and Waste Material, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C. (July 1974).

3-4. "Internal Combustion Engines: 1965 through 1974," Current Industrial Reports Series, MA-35L (65 through 74)-1, U.S. Bureau of the Census, Washington, D.C. (1975).

3-5. V. DeBiasi, "Double Standard on Fuel Oils Would Favor Steam over Gas Turbine Plants," Gas Turbine World (September 1973).

SECTION IV

CHEMICAL MANUFACTURING

4.1 INTRODUCTION

The emission sources discussed in this section are classified under the general process category of chemical manufacturing and the more specific categories of carbon black and ammonia manufacturing. The emissions under consideration are oxides of nitrogen (NO_x), hydrocarbons (HC), carbon monoxide (CO), and particulate (PART) matter.

This section describes the development of the data base used to calculate emissions from chemical manufacturing. The development of emission equations is described in Section 1, Data Handling. Chemical manufacturing processes studies are defined according to the National Emissions Data System (NEDS) Source Classification Code (SCC) and, in Table 4-1, by the NEDS Modified Source Classification Code (MSCC) developed by The Aerospace Corporation for this study.

4.2 SUMMARY

Chemical manufacturing production rates and emissions are defined for 1975, 1980, 1976, and 1981. These data are respectively listed in Tables 4-2-a, 4-3-a, 4-4-a, and 4-5-a. The respective uncertainties in the production and emission data are listed in Tables 4-2-b, 4-3-b, 4-4-b, and 4-5-b. Table 4-1 describes the process and production rate (charge rate) unit for each MSCC for which emissions were determined.

(Continued on page 4-15)

Table 4-1. DEFINITION OF CHEMICAL MANUFACTURING PROCESSES

MSCC	Source Category	Charge Rate Unit
301002010	Purge gas in ammonia plant with methanator	Tons/yr
301002020	Storage and loading in ammonia plant with methanator	
301003010	Regenerator exit in ammonia plant with CO absorber	
301003020	Purge gas in ammonia plant with CO absorber	
301003030	Storage and loading in ammonia plant with CO absorber	
301003990	Miscellaneous processes in ammonia plant with CO absorber	
301005010	Channel process carbon black production	
301005020	Thermal processes carbon black production	
301005030	Gas-fired furnace process carbon black production	
301005040	Oil-fired furnace process carbon black production	
301005050	Gas- and oil-fired furnace process carbon black production	
301005991	SIC 2952 sector of miscellaneous carbon black processes	
301005992	SIC 3624 sector of miscellaneous carbon black processes	
301005993	SIC 3999 sector of miscellaneous carbon black processes	
301005994	SIC 2899 sector of miscellaneous carbon black processes	
301005995	All other SICs of sector of miscellaneous carbon black processes	
301999991	SIC 2818 sector of miscellaneous chemical manufacturing	
301999992	SIC 3999 sector of miscellaneous chemical manufacturing	
301999993	All other SICs of sector of miscellaneous chemical manufacturing	

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[a] Standard industrial classification (SIC). The product description corresponding to each SIC is given in Ref. 4-1.

Table 4-2-a. 1975 CHEMICAL MANUFACTURING EMISSIONS AND CHARGE RATES

INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
301002000	6106000.	NEGLIGIBLE	.209	.003	NEGLIGIBLE
301002010	5235000.	NEGLIGIBLE	.209	.003	NEGLIGIBLE
301002020	871000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003000	2443000.	NEGLIGIBLE	.031	.046	NEGLIGIBLE
301003010	769000.	NEGLIGIBLE	.001	.046	NEGLIGIBLE
301003020	743000.	NEGLIGIBLE	.030	0.000	NEGLIGIBLE
301003030	555000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003990	376000.	NEGLIGIBLE	.000	0.000	NEGLIGIBLE
301005000	6054400.	NEGLIGIBLE	.322	2.241	NEGLIGIBLE
301005010	126700.	NEGLIGIBLE	.112	.508	NEGLIGIBLE
301005020	216800.	NEGLIGIBLE	.000	.003	NEGLIGIBLE
301005030	31800.	NEGLIGIBLE	.027	.084	NEGLIGIBLE
301005040	491400.	NEGLIGIBLE	.103	.552	NEGLIGIBLE
301005050	641100.	NEGLIGIBLE	.071	1.040	NEGLIGIBLE
301005990	4546600.	NEGLIGIBLE	.004	.055	NEGLIGIBLE
301005991	4003000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301005992	425400.	NEGLIGIBLE	.004	.009	NEGLIGIBLE
301005993	24330.	NEGLIGIBLE	.005	.045	NEGLIGIBLE
301005994	44550.	NEGLIGIBLE	.000	.000	NEGLIGIBLE
301005995	49290.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301999000	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999990	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999991	70000000.	NEGLIGIBLE	.276	.067	NEGLIGIBLE
301999992	181500.	NEGLIGIBLE	.018	.153	NEGLIGIBLE
301999993	81000000.	NEGLIGIBLE	.224	.116	NEGLIGIBLE

Table 4-2-b. 1975 CHEMICAL MANUFACTURING UNCERTAINTIES

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                 INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                 PAGE  1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975       RUN DATE= MAR 22,1977
                                          EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP                                                       PART
   SCC        (SCC UNITS)        NOX             HC            CO

 301002000   +     229110.     NEGLIGIBLE     +  .028      +  .001      NEGLIGIBLE
             -     229110.     NEGLIGIBLE     -  .028      -  .001      NEGLIGIBLE

 301002010   +     226000.     NEGLIGIBLE     +  .028      +  .001      NEGLIGIBLE
             -     226000.     NEGLIGIBLE     -  .028      -  .001      NEGLIGIBLE
 301002020   +      37599.     NEGLIGIBLE     + 0.000      + 0.000      NEGLIGIBLE
             -      37599.     NEGLIGIBLE     - 0.000      - 0.000      NEGLIGIBLE

 301003000   +      54487.     NEGLIGIBLE     +  .004      +  .031      NEGLIGIBLE
             -      54487.     NEGLIGIBLE     -  .004      -  .031      NEGLIGIBLE

 301003010   +      33199.     NEGLIGIBLE     +  .000      +  .031      NEGLIGIBLE
             -      33199.     NEGLIGIBLE     -  .000      -  .031      NEGLIGIBLE
 301003020   +      32080.     NEGLIGIBLE     +  .004      + 0.000      NEGLIGIBLE
             -      32080.     NEGLIGIBLE     -  .004      - 0.000      NEGLIGIBLE
 301003030   +      23960.     NEGLIGIBLE     + 0.000      + 0.000      NEGLIGIBLE
             -      23960.     NEGLIGIBLE     - 0.000      - 0.000      NEGLIGIBLE
 301003990   +      16230.     NEGLIGIBLE     +  .000      + 0.000      NEGLIGIBLE
             -      16230.     NEGLIGIBLE     -  .000      - 0.000      NEGLIGIBLE

 301005000   +     226540.     NEGLIGIBLE     +  .072      +  .340      NEGLIGIBLE
             -     226540.     NEGLIGIBLE     -  .072      -  .340      NEGLIGIBLE

 301005010   +      79830.     NEGLIGIBLE     +  .071      +  .321      NEGLIGIBLE
             -      79830.     NEGLIGIBLE     -  .071      -  .321      NEGLIGIBLE
 301005020   +      17799.     NEGLIGIBLE     +  .000      +  .000      NEGLIGIBLE
             -      17799.     NEGLIGIBLE     -  .000      -  .000      NEGLIGIBLE
 301005030   +       2550.     NEGLIGIBLE     +  .003      +  .007      NEGLIGIBLE
             -       2550.     NEGLIGIBLE     -  .003      -  .007      NEGLIGIBLE
 301005040   +      39400.     NEGLIGIBLE     +  .009      +  .052      NEGLIGIBLE
             -      39400.     NEGLIGIBLE     -  .009      -  .051      NEGLIGIBLE
 301005050   +      51400.     NEGLIGIBLE     +  .007      +  .098      NEGLIGIBLE
             -      51400.     NEGLIGIBLE     -  .006      -  .098      NEGLIGIBLE
 301005990   +     201070.     NEGLIGIBLE     +  .001      +  .005      NEGLIGIBLE
             -     201070.     NEGLIGIBLE     -  .001      -  .005      NEGLIGIBLE

 301005991   +     200000.     NEGLIGIBLE     + 0.000      + 0.000      NEGLIGIBLE
             -     200000.     NEGLIGIBLE     - 0.000      - 0.000      NEGLIGIBLE
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Table 4-2-b. 1975 CHEMICAL MANUFACTURING UNCERTAINTIES (Continued)

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                    INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING              PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)       NOX              HC              CO          PART
301005992  +          19999.    NEGLIGIBLE   +   .000        +   .001      NEGLIGIBLE
           -          19999.    NEGLIGIBLE   -   .000        -   .001      NEGLIGIBLE
301005993  +           1000.    NEGLIGIBLE   +   .001        +   .005      NEGLIGIBLE
           -           1000.    NEGLIGIBLE   -   .001        -   .005      NEGLIGIBLE
301005994  +           2000.    NEGLIGIBLE   +   .000        +   .000      NEGLIGIBLE
           -           2000.    NEGLIGIBLE   -   .000        -   .000      NEGLIGIBLE
301005995  +           4999.    NEGLIGIBLE   +  0.000        +  0.000      NEGLIGIBLE
           -           4999.    NEGLIGIBLE   -  0.000        -  0.000      NEGLIGIBLE

301999000  +       17464000.    NEGLIGIBLE   +   .065        +   .129      NEGLIGIBLE
           -       17464000.    NEGLIGIBLE   -   .065        -   .129      NEGLIGIBLE
301999990  +       17464000.    NEGLIGIBLE   +   .065        +   .129      NEGLIGIBLE
           -       17464000.    NEGLIGIBLE   -   .065        -   .129      NEGLIGIBLE
301999991  +        7000000.    NEGLIGIBLE   +   .033        +   .010      NEGLIGIBLE
           -        7000000.    NEGLIGIBLE   -   .039        -   .010      NEGLIGIBLE
301999992  +          19999.    NEGLIGIBLE   +   .011        +   .126      NEGLIGIBLE
           -          19999.    NEGLIGIBLE   -   .011        -   .126      NEGLIGIBLE
301999993  +       16000000.    NEGLIGIBLE   +   .050        +   .026      NEGLIGIBLE
           -       16000000.    NEGLIGIBLE   -   .050        -   .026      NEGLIGIBLE
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Table 4-3-a. 1980 CHEMICAL MANUFACTURING EMISSIONS AND CHARGE RATES

INDUSTRIAL PRECESS, CHEMICAL MANUFACTURING PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
301002000	7083000.	NEGLIGIBLE	.243	.003	NEGLIGIBLE
301002010	6073000.	NEGLIGIBLE	.243	.003	NEGLIGIBLE
301002020	1010000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003000	2832500.	NEGLIGIBLE	.036	.054	NEGLIGIBLE
301003010	892000.	NEGLIGIBLE	.001	.054	NEGLIGIBLE
301003020	861500.	NEGLIGIBLE	.034	0.000	NEGLIGIBLE
301003030	643500.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003990	435500.	NEGLIGIBLE	.000	0.000	NEGLIGIBLE
301005000	6217000.	NEGLIGIBLE	.328	2.359	NEGLIGIBLE
301005010	105960.	NEGLIGIBLE	.094	.425	NEGLIGIBLE
301005020	254010.	NEGLIGIBLE	.000	.004	NEGLIGIBLE
301005030	35795.	NEGLIGIBLE	.031	.094	NEGLIGIBLE
301005040	553100.	NEGLIGIBLE	.116	.621	NEGLIGIBLE
301005050	721600.	NEGLIGIBLE	.079	1.170	NEGLIGIBLE
301005990	4546800.	NEGLIGIBLE	.009	.055	NEGLIGIBLE
301005991	4003000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301005992	425400.	NEGLIGIBLE	.004	.009	NEGLIGIBLE
301005993	24330.	NEGLIGIBLE	.005	.045	NEGLIGIBLE
301005994	44550.	NEGLIGIBLE	.000	.000	NEGLIGIBLE
301005995	49290.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301999000	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999990	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999991	70000000.	NEGLIGIBLE	.276	.067	NEGLIGIBLE
301999992	181500.	NEGLIGIBLE	.018	.153	NEGLIGIBLE
301999993	81000000.	NEGLIGIBLE	.224	.116	NEGLIGIBLE

Table 4-3-b. 1980 CHEMICAL MANUFACTURING UNCERTAINTIES

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                        INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING                  PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980          RUN DATE= MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED          TACRP                                                              PART
  SCC          (SCC UNITS)          NOX            HC              CO
301002000   +    288470.      NEGLIGIBLE     +  .032       +  .001         NEGLIGIBLE
            -    288470.      NEGLIGIBLE     -  .032       -  .001         NEGLIGIBLE

301002010   +    284580.      NEGLIGIBLE     +  .032       +  .001         NEGLIGIBLE
            -    284580.      NEGLIGIBLE     -  .032       -  .001         NEGLIGIBLE
301002020   +     47180.      NEGLIGIBLE     + 0.000       + 0.000         NEGLIGIBLE
            -     47180.      NEGLIGIBLE     - 0.000       - 0.000         NEGLIGIBLE

301003000   +     68686.      NEGLIGIBLE     +  .005       +  .036         NEGLIGIBLE
            -     68686.      NEGLIGIBLE     -  .005       -  .036         NEGLIGIBLE

301003010   +     41862.      NEGLIGIBLE     +  .000       +  .036         NEGLIGIBLE
            -     41862.      NEGLIGIBLE     -  .000       -  .036         NEGLIGIBLE
301003020   +     40365.      NEGLIGIBLE     +  .005       + 0.000         NEGLIGIBLE
            -     40365.      NEGLIGIBLE     -  .005       - 0.000         NEGLIGIBLE
301003030   +     30270.      NEGLIGIBLE     + 0.000       + 0.000         NEGLIGIBLE
            -     30270.      NEGLIGIBLE     - 0.000       - 0.000         NEGLIGIBLE
301003990   +     20485.      NEGLIGIBLE     +  .000       + 0.000         NEGLIGIBLE
            -     20485.      NEGLIGIBLE     -  .000       - 0.000         NEGLIGIBLE

301005000   +    237320.      NEGLIGIBLE     +  .087       +  .411         NEGLIGIBLE
            -    237320.      NEGLIGIBLE     -  .087       -  .411         NEGLIGIBLE

301005010   +     96857.      NEGLIGIBLE     +  .086       +  .389         NEGLIGIBLE
            -     96857.      NEGLIGIBLE     -  .086       -  .389         NEGLIGIBLE
301005020   +     20185.      NEGLIGIBLE     +  .000       +  .000         NEGLIGIBLE
            -     20185.      NEGLIGIBLE     -  .000       -  .000         NEGLIGIBLE
301005030   +      3070.      NEGLIGIBLE     +  .003       +  .008         NEGLIGIBLE
            -      3070.      NEGLIGIBLE     -  .003       -  .008         NEGLIGIBLE
301005040   +     47482.      NEGLIGIBLE     +  .011       +  .062         NEGLIGIBLE
            -     47482.      NEGLIGIBLE     -  .011       -  .061         NEGLIGIBLE
301005050   +     61941.      NEGLIGIBLE     +  .008       +  .116         NEGLIGIBLE
            -     61941.      NEGLIGIBLE     -  .007       -  .116         NEGLIGIBLE
301005990   +    201070.      NEGLIGIBLE     +  .001       +  .005         NEGLIGIBLE
            -    201070.      NEGLIGIBLE     -  .001       -  .005         NEGLIGIBLE

301005991   +    200000.      NEGLIGIBLE     + 0.000       + 0.000         NEGLIGIBLE
            -    200000.      NEGLIGIBLE     - 0.000       - 0.000         NEGLIGIBLE
```

Table 4-3-b. 1980 CHEMICAL MANUFACTURING UNCERTAINTIES (Continued)

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                           INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                 PAGE  2
     TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975         RUN DATE= MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
      MODIFIED          TACRP                                  HC              CO              PART
        SCC          (SCC UNITS)            NOX

     301005992   +       19999.       NEGLIGIBLE     +  .000       +  .001      NEGLIGIBLE
                 -       19999.       NEGLIGIBLE     -  .000       -  .001      NEGLIGIBLE
     301005993   +        1000.       NEGLIGIBLE     +  .001       +  .005      NEGLIGIBLE
                 -        1000.       NEGLIGIBLE     -  .001       -  .005      NEGLIGIBLE
     301005994   +        2000.       NEGLIGIBLE     +  .000       +  .000      NEGLIGIBLE
                 -        2000.       NEGLIGIBLE     -  .000       -  .000      NEGLIGIBLE
     301005995   +        4999.       NEGLIGIBLE     + 0.000       + 0.000      NEGLIGIBLE
                 -        4999.       NEGLIGIBLE     - 0.000       - 0.000      NEGLIGIBLE

     301999000   +    17464000.       NEGLIGIBLE     +  .065       +  .129      NEGLIGIBLE
                 -    17464000.       NEGLIGIBLE     -  .065       -  .129      NEGLIGIBLE

     301999990   +    17464000.       NEGLIGIBLE     +  .065       +  .129      NEGLIGIBLE
                 -    17464000.       NEGLIGIBLE     -  .065       -  .129      NEGLIGIBLE

     301999991   +     7000000.       NEGLIGIBLE     +  .039       +  .010      NEGLIGIBLE
                 -     7000000.       NEGLIGIBLE     -  .039       -  .010      NEGLIGIBLE
     301999992   +       19999.       NEGLIGIBLE     +  .011       +  .126      NEGLIGIBLE
                 -       19999.       NEGLIGIBLE     -  .011       -  .126      NEGLIGIBLE
     301999993   +    16000000.       NEGLIGIBLE     +  .050       +  .026      NEGLIGIBLE
                 -    16000000.       NEGLIGIBLE     -  .050       -  .026      NEGLIGIBLE
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Table 4-4-a. 1976 CHEMICAL MANUFACTURING EMISSIONS AND CHARGE RATES

INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
301002000	6301400.	NEGLIGIBLE	.216	.003	NEGLIGIBLE
301002010	5402600.	NEGLIGIBLE	.216	.003	NEGLIGIBLE
301002020	898800.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003000	2520900.	NEGLIGIBLE	.032	.048	NEGLIGIBLE
301003010	793600.	NEGLIGIBLE	.001	.048	NEGLIGIBLE
301003020	766700.	NEGLIGIBLE	.031	0.000	NEGLIGIBLE
301003030	572700.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301003990	387900.	NEGLIGIBLE	.000	0.000	NEGLIGIBLE
301005000	6086900.	NEGLIGIBLE	.323	2.267	NEGLIGIBLE
301005010	122550.	NEGLIGIBLE	.108	.492	NEGLIGIBLE
301005020	224240.	NEGLIGIBLE	.000	.003	NEGLIGIBLE
301005030	32599.	NEGLIGIBLE	.028	.086	NEGLIGIBLE
301005040	503740.	NEGLIGIBLE	.105	.565	NEGLIGIBLE
301005050	657200.	NEGLIGIBLE	.072	1.066	NEGLIGIBLE
301005990	4546600.	NEGLIGIBLE	.009	.055	NEGLIGIBLE
301005991	4003000.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301005992	425400.	NEGLIGIBLE	.004	.009	NEGLIGIBLE
301005993	24330.	NEGLIGIBLE	.005	.345	NEGLIGIBLE
301005994	44550.	NEGLIGIBLE	.000	.000	NEGLIGIBLE
301005995	49290.	NEGLIGIBLE	0.000	0.000	NEGLIGIBLE
301999000	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999990	151180000.	NEGLIGIBLE	.518	.336	NEGLIGIBLE
301999991	70000000.	NEGLIGIBLE	.276	.067	NEGLIGIBLE
301999992	181500.	NEGLIGIBLE	.018	.153	NEGLIGIBLE
301999993	81000000.	NEGLIGIBLE	.224	.116	NEGLIGIBLE

Table 4-4-b. 1976 CHEMICAL MANUFACTURING UNCERTAINTIES

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                 INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                         PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976         RUN DATE= MAR 22,1977
 MODIFIED            TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)        NOX               HC              CO            PART

301002000    +        231770.     NEGLIGIBLE      +  .029        +  .001       NEGLIGIBLE
             -        231770.     NEGLIGIBLE      -  .029        -  .001       NEGLIGIBLE

301002010    +        228630.     NEGLIGIBLE      +  .029        +  .001       NEGLIGIBLE
             -        228630.     NEGLIGIBLE      -  .029        -  .001       NEGLIGIBLE
301002020    +         38029.     NEGLIGIBLE      + 0.000        + 0.000       NEGLIGIBLE
             -         38029.     NEGLIGIBLE      - 0.000        - 0.000       NEGLIGIBLE

301003000    +         55125.     NEGLIGIBLE      +  .004        +  .032       NEGLIGIBLE
             -         55125.     NEGLIGIBLE      -  .004        -  .032       NEGLIGIBLE

301003010    +         33589.     NEGLIGIBLE      +  .000        +  .032       NEGLIGIBLE
             -         33589.     NEGLIGIBLE      -  .000        -  .032       NEGLIGIBLE
301003020    +         32452.     NEGLIGIBLE      +  .004        + 0.000       NEGLIGIBLE
             -         32452.     NEGLIGIBLE      -  .004        - 0.000       NEGLIGIBLE
301003030    +         24244.     NEGLIGIBLE      + 0.000        + 0.000       NEGLIGIBLE
             -         24244.     NEGLIGIBLE      - 0.000        - 0.000       NEGLIGIBLE
301003990    +         16421.     NEGLIGIBLE      +  .000        + 0.000       NEGLIGIBLE
             -         16421.     NEGLIGIBLE      -  .000        - 0.000       NEGLIGIBLE

301005000    +        226980.     NEGLIGIBLE      +  .072        +  .343       NEGLIGIBLE
             -        226980.     NEGLIGIBLE      -  .072        -  .343       NEGLIGIBLE

301005010    +         80580.     NEGLIGIBLE      +  .071        +  .324       NEGLIGIBLE
             -         80580.     NEGLIGIBLE      -  .071        -  .324       NEGLIGIBLE
301005020    +         17901.     NEGLIGIBLE      +  .000        +  .000       NEGLIGIBLE
             -         17901.     NEGLIGIBLE      -  .000        -  .000       NEGLIGIBLE
301005030    +          2572.     NEGLIGIBLE      +  .003        +  .007       NEGLIGIBLE
             -          2572.     NEGLIGIBLE      -  .003        -  .007       NEGLIGIBLE
301005040    +         39754.     NEGLIGIBLE      +  .009        +  .053       NEGLIGIBLE
             -         39754.     NEGLIGIBLE      -  .009        -  .052       NEGLIGIBLE
301005050    +         51862.     NEGLIGIBLE      +  .007        +  .100       NEGLIGIBLE
             -         51862.     NEGLIGIBLE      -  .006        -  .100       NEGLIGIBLE
301005990    +        201070.     NEGLIGIBLE      +  .001        +  .005       NEGLIGIBLE
             -        201070.     NEGLIGIBLE      -  .001        -  .005       NEGLIGIBLE

301005991    +        200000.     NEGLIGIBLE      + 0.000        + 0.000       NEGLIGIBLE
             -        200000.     NEGLIGIBLE      - 0.000        - 0.000       NEGLIGIBLE
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Table 4-4-b. 1976 CHEMICAL MANUFACTURING UNCERTAINTIES (Continued)

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                   INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING          PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976       RUN DATE= MAR 22,1977
 MODIFIED          TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX             HC              CO           PART

301005992    +         19999.      NEGLIGIBLE     +  .000         +  .001      NEGLIGIBLE
             -         19999.      NEGLIGIBLE     -  .000         -  .001      NEGLIGIBLE
301005993    +          1000.      NEGLIGIBLE     +  .001         +  .005      NEGLIGIBLE
             -          1000.      NEGLIGIBLE     -  .001         -  .005      NEGLIGIBLE
301005994    +          2000.      NEGLIGIBLE     +  .000         +  .000      NEGLIGIBLE
             -          2000.      NEGLIGIBLE     -  .000         -  .000      NEGLIGIBLE
301005995    +          4999.      NEGLIGIBLE     + 0.000         + 0.000      NEGLIGIBLE
             -          4999.      NEGLIGIBLE     - 0.000         - 0.000      NEGLIGIBLE

301999000    +      17464000.      NEGLIGIBLE     +  .065         +  .129      NEGLIGIBLE
             -      17464000.      NEGLIGIBLE     -  .065         -  .129      NEGLIGIBLE

301999990    +      17464000.      NEGLIGIBLE     +  .065         +  .129      NEGLIGIBLE
             -      17464000.      NEGLIGIBLE     -  .065         -  .129      NEGLIGIBLE

301999991    +       7000000.      NEGLIGIBLE     +  .039         +  .010      NEGLIGIBLE
             -       7000000.      NEGLIGIBLE     -  .039         -  .010      NEGLIGIBLE
301999992    +         19999.      NEGLIGIBLE     +  .011         +  .126      NEGLIGIBLE
             -         19999.      NEGLIGIBLE     -  .011         -  .126      NEGLIGIBLE
301999993    +      16000000.      NEGLIGIBLE     +  .050         +  .026      NEGLIGIBLE
             -      16000000.      NEGLIGIBLE     -  .050         -  .026      NEGLIGIBLE
```

Table 4-5-a. 1981 CHEMICAL MANUFACTURING EMISSIONS AND CHARGE RATES

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                    INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING            PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED          TACRP                       EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX                HC             CO           PART

301002000         7278400.       NEGLIGIBLE           .256           .003       NEGLIGIBLE

301002010         6240600.       NEGLIGIBLE           .250           .003       NEGLIGIBLE
301002020         1037800.       NEGLIGIBLE          0.000          0.000       NEGLIGIBLE

301003000         2910400.       NEGLIGIBLE           .037           .055       NEGLIGIBLE

301003010          916600.       NEGLIGIBLE           .001           .055       NEGLIGIBLE
301003020          935200.       NEGLIGIBLE           .035          0.000       NEGLIGIBLE
301003030          661200.       NEGLIGIBLE          0.000          0.000       NEGLIGIBLE
301003990          447400.       NEGLIGIBLE           .000          0.000       NEGLIGIBLE

301005000         6249600.       NEGLIGIBLE           .330          2.394       NEGLIGIBLE

301005010         1018[illegible]0.       NEGLIGIBLE           .090           .408       NEGLIGIBLE
301005020          261450.       NEGLIGIBLE           .000           .004       NEGLIGIBLE
301005030           36594.       NEGLIGIBLE           .031           .096       NEGLIGIBLE
301005040          565440.       NEGLIGIBLE           .118           .635       NEGLIGIBLE
301005050          737700.       NEGLIGIBLE           .081          1.197       NEGLIGIBLE
301005990         4546600.       NEGLIGIBLE           .009           .355       NEGLIGIBLE

301005991         4003000.       NEGLIGIBLE          0.000          0.000       NEGLIGIBLE
301005992          425400.       NEGLIGIBLE           .004           .009       NEGLIGIBLE
301005993           24330.       NEGLIGIBLE           .005           .045       NEGLIGIBLE
301005994           44550.       NEGLIGIBLE           .000           .000       NEGLIGIBLE
301005995           49290.       NEGLIGIBLE          0.000          0.000       NEGLIGIBLE

301999000       151180000.       NEGLIGIBLE           .518           .336       NEGLIGIBLE

301999990       151180000.       NEGLIGIBLE           .518           .336       NEGLIGIBLE

301999991        70000000.       NEGLIGIBLE           .276           .067       NEGLIGIBLE
301999992          181500.       NEGLIGIBLE           .018           .193       NEGLIGIBLE
301999993        81000000.       NEGLIGIBLE           .224           .116       NEGLIGIBLE
```

Table 4-5-b. 1981 CHEMICAL MANUFACTURING UNCERTAINTIES

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                         INDUSTRIAL PRCCESS, CHEMICAL MANUFACTURING                 PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981              RUN DATE= MAR 22,1977
                                          EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED          TACRP                                HC              CO          PART
   SCC         (SCC UNITS)            NOX
                                                                   +   .001      NEGLIGIBLE
301002000   +       311020.         NEGLIGIBLE      +   .034      -   .001      NEGLIGIBLE
            -       311020.         NEGLIGIBLE      -   .034

301002010   +       306840.         NEGLIGIBLE      +   .034      +   .001      NEGLIGIBLE
            -       306840.         NEGLIGIBLE      -   .034      -   .001      NEGLIGIBLE
301002020   +        50827.         NEGLIGIBLE      + 0.000       + 0.000       NEGLIGIBLE
            -        50827.         NEGLIGIBLE      - 0.000       - 0.000       NEGLIGIBLE

301003000   +        74077.         NEGLIGIBLE      +   .005      +   .037      NEGLIGIBLE
            -        74077.         NEGLIGIBLE      -   .005      -   .037      NEGLIGIBLE

301003010   +        45150.         NEGLIGIBLE      +   .000      +   .037      NEGLIGIBLE
            -        45150.         NEGLIGIBLE      -   .000      -   .037      NEGLIGIBLE
301003020   +        43514.         NEGLIGIBLE      +   .005      + 0.000       NEGLIGIBLE
            -        43514.         NEGLIGIBLE      -   .005      - 0.000       NEGLIGIBLE
301003030   +        32663.         NEGLIGIBLE      + 0.000       + 0.000       NEGLIGIBLE
            -        32663.         NEGLIGIBLE      - 0.000       - 0.000       NEGLIGIBLE
301003990   +        22100.         NEGLIGIBLE      +   .000      + 0.000       NEGLIGIBLE
            -        22100.         NEGLIGIBLE      -   .000      - 0.000       NEGLIGIBLE

301005000   +       241910.         NEGLIGIBLE      +   .093      +   .430      NEGLIGIBLE
            -       241200.         NEGLIGIBLE      -   .091      -   .431      NEGLIGIBLE

301005010   +       103670.         NEGLIGIBLE      +   .092      +   .416      NEGLIGIBLE
            -       101810.         NEGLIGIBLE      -   .090      -   .408      NEGLIGIBLE
301005020   +        21150.         NEGLIGIBLE      +   .000      +   .000      NEGLIGIBLE
            -        21150.         NEGLIGIBLE      -   .000      -   .000      NEGLIGIBLE
301005030   +         3273.         NEGLIGIBLE      +   .003      +   .009      NEGLIGIBLE
            -         3273.         NEGLIGIBLE      -   .003      -   .009      NEGLIGIBLE
301005040   +        50632.         NEGLIGIBLE      +   .012      +   .065      NEGLIGIBLE
            -        50632.         NEGLIGIBLE      -   .012      -   .064      NEGLIGIBLE
301005050   +        66048.         NEGLIGIBLE      +   .008      +   .123      NEGLIGIBLE
            -        66048.         NEGLIGIBLE      -   .007      -   .123      NEGLIGIBLE
301005990   +       201070.         NEGLIGIBLE      +   .001      +   .005      NEGLIGIBLE
            -       201070.         NEGLIGIBLE      -   .001      -   .005      NEGLIGIBLE

301005991   +       200000.         NEGLIGIBLE      + 0.000       + 0.000       NEGLIGIBLE
            -       200000.         NEGLIGIBLE      - 0.000       - 0.000       NEGLIGIBLE
```

Table 4-5-b. 1981 CHEMICAL MANUFACTURING UNCERTAINTIES (Continued)

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                      INDUSTRIAL PROCESS, CHEMICAL MANUFACTURING                    PAGE  2
          TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981        RUN DATE= MAR 22,1977
  MODIFIED           TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC           (SCC UNITS)         NOX              HC              CO             PART

  301005992   +        19999.     NEGLIGIBLE     +   .000       +   .001       NEGLIGIBLE
              -        19999.     NEGLIGIBLE     -   .000       -   .001       NEGLIGIBLE
  301005993   +         1000.     NEGLIGIBLE     +   .001       +   .005       NEGLIGIBLE
              -         1000.     NEGLIGIBLE     -   .001       -   .005       NEGLIGIBLE
  301005994   +         2000.     NEGLIGIBLE     +   .000       +   .000       NEGLIGIBLE
              -         2000.     NEGLIGIBLE     -   .000       -   .000       NEGLIGIBLE
  301005995   +         4999.     NEGLIGIBLE     + 0.000        + 0.000        NEGLIGIBLE
              -         4999.     NEGLIGIBLE     - 0.000        - 0.000        NEGLIGIBLE

  301999000   +     17464000.     NEGLIGIBLE     +   .065       +   .129       NEGLIGIBLE
              -     17464000.     NEGLIGIBLE     -   .065       -   .129       NEGLIGIBLE

  301999990   +     17464000.     NEGLIGIBLE     +   .065       +   .129       NEGLIGIBLE
              -     17464000.     NEGLIGIBLE     -   .065       -   .129       NEGLIGIBLE

  301999991   +      7000000.     NEGLIGIBLE     +   .039       +   .010       NEGLIGIBLE
              -      7000000.     NEGLIGIBLE     -   .039       -   .010       NEGLIGIBLE
  301999992   +        19999.     NEGLIGIBLE     +   .011       +   .126       NEGLIGIBLE
              -        19999.     NEGLIGIBLE     -   .011       -   .126       NEGLIGIBLE
  301999993   +     16000000.     NEGLIGIBLE     +   .050       +   .026       NEGLIGIBLE
              -     16000000.     NEGLIGIBLE     -   .050       -   .026       NEGLIGIBLE
```

4.3 EMISSION ANALYSIS

The NEDS categorizes chemical manufacturing as a member of the industrial process family of stationary sources of emissions (Ref. 4-2). Industrial process emissions are compared to other point sources in Table 4-6. Industrial process emissions for chemical manufacturing (SCC 3-01-xxx-xx) are compared in Table 4-7 with emissions from the petroleum industry and other members of the industrial process group. The PART and NO_x emissions from chemical manufacturing represent a small fraction, approximately three percent and four percent, respectively, of total industrial process emissions. Since the PART and NO_x emissions from chemical manufacturing processes represent such small fractions of the totals from stationary sources, these pollutants were largely neglected in this study.

The charge rate, emissions, and other pertinent data were extracted from the NEDS point source data for each of the 143 SCC process categories in the chemical manufacturing group. Table 4-8 ranks the categories with the highest charge rates. Tables 4-9 and 4-10, respectively, list the most significant chemical manufacturing emitters by SCC category and product for HC and CO emissions. In comparing the process categories that produce the most emissions (Tables 4-9 and 4-10) to those having the highest charge rates (Table 4-8), it is seen that the miscellaneous synthetic rubber production (3-01-026-99) and the ammonium nitrate prilling tower cooler (3-01-027-03) categories have high charge rates, but are not producers of the largest amount of pollutants.

As a check against erroneous data, the effective emission factors from the NEDS data (emissions and charge rate) were compared with data published elsewhere. Although little data were available (data were obtained only from Refs. 4-4 and 4-5), good agreement existed where comparisons could be made. These comparisons plus a general knowledge

(Continued on page 4-21)

Table 4-6. NATIONWIDE POINT SOURCE EMISSIONS[a]

Source Category	Emissions, ~ tons/yr			
	PART	NO_x	HC	CO
Fuel Combustion	5,414,427	8,922,937	239,403	645,880
Industrial Processes	8,427,012	3,728,717	7,033,590	21,132,667
Other Point Sources	150,847	29,725	165,847	5,455,023
Total	13,992,286	12,681,379	7,438,840	27,233,570

[a] Ref. 4-3.

Table 4-7. INDUSTRIAL PROCESS EMISSIONS[a]

Source Category	PART	NO_x	HC	CO
Total Industrial Process Emissions, tons/yr				
Chemical Manufacturing: SCC 3-01-xxx-xx	232,886 (2.76%)	155,068 (4.16%)	2,319,544 (32.98%)	5,992,262 (28.36%)
Petroleum Industry: SCC 3-06-xxx-xx	1,036,281 (12.30%)	3,264,812 (87.56%)	1,012,131 (14.39%)	4,524,476 (21.41%)
Other Industrial Processes[b]	7,157,845 (84.94%)	308,837 (8.28%)	3,701,915 (52.63%)	10,615,929 (50.23%)
Total Industrial Processes	8,427,012 (100%)	3,728,717 (100%)	7,033,590 (100%)	21,132,667 (100%)
Total Nationwide Point Source Emissions, %				
Chemical Manufacturing	1.7	1.2	31.2	22.0
Petroleum Industry	7.4	25.7	13.6	16.6
Other Industrial Processes	51.2	2.4	48.8	39.0
Total Industrial Processes	60.2	29.4	94.6	77.6

[a] Ref. 4-3.

[b] Includes such processes as food, agriculture, primary metals, and secondary metals.

Table 4-8. PRODUCERS OF GREATEST EMISSIONS IN CHEMICAL MANUFACTURING

Rank	SCC	Number of Point Sources	Source Category	Annual Production Rate, tons/yr[a]
1	3-01-999-99	1944	Miscellaneous chemical manufacturing	151.29×10^6
2	3-01-026-99	189	Miscellaneous synthetic rubber production	13.63×10^6
3	3-01-021-99	40	Miscellaneous sodium carbonate production	11.67×10^6
4	3-01-018-99	225	Miscellaneous plastics production	5.30×10^6
5	3-01-005-99	74	Miscellaneous carbon black production	4.75×10^6
6	3-01-002-01	33	Ammonia production with methanator	4.62×10^6
7[b]	3-01-027-03	41	Ammonium nitrate with prilling tower	4.25×10^6

[a] Also known as annual charge rate (ACR).

[b] These categories were not among the five categories yielding the greatest emissions in the chemical manufacturing group.

Table 4-9. PRODUCERS OF GREATEST HC EMISSIONS IN CHEMICAL MANUFACTURING

Rank by Emissions

Rank	SCC	Source Category	Effective Emission Factor, lb/ton[a]	Emission Rate, tons/yr
1	3-01-999-99	Miscellaneous chemical manufacturing	6.86	519×10^3
2	3-01-005-01	Carbon black, channel	1767.	227×10^3
3	3-01-002-01	Ammonia with methanator	69.2	160×10^3
4	3-01-005-04	Carbon black, furnace oil	425.	82×10^3
5	3-01-018-99	Miscellaneous plastics production	30.6	81×10^3

Rank by Product

Rank	Product	Production Rate		Emission Rate	
		Tons/yr	%	Tons/yr	%
1	Carbon black	0.634×10^6	0.4	309×10^3	29
2	Ammonia	4.622×10^6	2.9	160×10^3	15
3	Plastics	5.296×10^6	3.3	81×10^3	8
4	Other	151.3×10^6	93.5	519×10^3	49
	Total	161.85×10^6	100	1069×10^3	100

[a] Effective emission factor is the emission rate (lb/yr) divided by the production rate (tons/yr).

Table 4-10. PRODUCERS OF GREATEST CO EMISSIONS IN CHEMICAL MANUFACTURING

Rank by Emissions

Rank	SCC	Source Category	Effective Emission Factor, lb/ton[a]	Emission Rate, tons/yr
1	3-01-005-01	Carbon black, channel	8031.	1032×10^3
2	3-01-005-05	Carbon black, furnace oil and gas	3246.	797×10^3
3	3-01-005-04	Carbon black, furnace oil	2137.	403×10^3
4	3-01-999-99	Miscellaneous chemical	4.44	336×10^3
5	3-01-005-03	Carbon black, furnace gas	5000.	60×10^3
6	3-01-005-99	Carbon black, miscellaneous processes	24.44	58×10^3

Rank by Product

Rank	Product	Production Rate		Emission Rate	
		Tons/yr	%	Tons/yr	%
1	Carbon black	5.90×10^6	3.8	2350×10^3	87
2	Miscellaneous chemical manufacturing	151.29×10^6	96.2	336×10^3	13
	Total	157.19×10^6	100	2686×10^3	100

[a] Effective emission factor is the emission rate (lb/yr) divided by the production rate (tons/yr).

of the subject process resulted in the elimination of synthetic rubber and ammonium nitrate manufacturing as major contributors of the four emissions of interest.

4.3.1 Chemical Manufacturing Processes Studied

As mentioned, only unburned HC and CO emissions were examined when forming the list of products and SCCs for which future charge rate and emission forecasts were to be made. All SCC categories related to an offending product were studied regardless of the magnitude of the current emissions represented by any one SCC. Table 4-9 shows that certain carbon black, ammonia, and miscellaneous chemical manufacturing emissions represent 93 percent of the HC emitted by the five largest producers in the chemical manufacturing category. Table 4-10 shows that certain carbon black manufacturing processes produce the most CO emissions in the chemical manufacturing group.

The chemical manufacturing products and SCC categories for which future emissions and production rates were projected are as follows:

SCC	Product
3-01-0002-xx	Ammonia made with methanator
3-01-003-xx	Ammonia made with CO absorber
3-01-005-xx	Carbon black
3-01-999-99	Miscellaneous chemical manufacturing

These four broad categories were divided into 19 MSCC categories, and a current data base and 1980 projection were made for each. More detailed definitions of these processes, as well as charge rates, are listed in Table 4-1.

4.3.2 General Observations

In the course of the chemical manufacturing emissions study, certain errors and discrepancies were noted in the NEDS point source emission data. Most of these observations were trivial, but two were believed sufficiently significant to be reported here.

4.3.2.1 Summary of Point Source Comparison

The charge rate (production) and emissions as extracted from the NEDS point source data (Ref. 4-6) are shown in Table 4-11 for the chemical manufacturing group. Although the years of record vary from 1969 to 1973 for the NEDS data, the preponderance of SCC data is for 1971. The emissions from Refs. 4-3, 4-6, and 4-7 are summarized in the following table and are presented graphically in Figure 4-1.

	Emissions, million tons/yr			
Data Source	PART	NO_x	HC	CO
NEDS Tape:				
1971	0.28	0.33	1.42	2.92
NEDS Nationwide Emission Summary Report:				
December 1973	0.22	0.15	2.37	6.01
January 1975	0.23	0.16	2.33	5.99

A discontinuity appears to exist between the 1971 and the 1974-75 data shown in Figure 4-1, indicating an inconsistency in ground rules or methods of establishing the two sets of data. Two known factors which may have contributed to the inconsistency are listed here. Their exact effects are unknown, but are believed to be significant.

a. Emissions listed on the NEDS tape are based frequently on preliminary (sometimes inaccurate) emission factors (Ref. 4-4) or in some cases simply a guess. A comparison of emission factors published in Refs. 4-4 and 4-5 reflects the size of certain data errors. These could cause either high or low emissions to be entered on the NEDS tape.

Table 4-11. SUMMARY OF CHEMICAL MANUFACTURING AND EMISSIONS REPORTED IN NEDS[a]

SCC	Annual Charge Rate[b]	Emissions, ~ tons/yr			
		PART	NO_x	HC	CO
3-01-002-01	4,621,676	118	3,259	160,008	2,777
3-01-002-02	766,500	-	-	-	-
3-01-002-99	-	-	-	-	-
3-01-002		118 (-%)	3,259 (1.0%)	160,008 (11.3%)	2,777 (0.1%)
3-01-003-01	679,793	40	65	772	10,995
3-01-003-02	651,996	119	-	2,510	-
3-01-003-03	486,877	-	-	-	-
3-01-003-99	330,000	-	-	331	-
3-01-003		159 (0.1%)	65 (-%)	3,613 (0.3%)	10,995 (0.4%)
3-01-005-01	257,163	22,146	-	227,337	1,031,710
3-01-005-02		-	-	-	-
3-01-005-03	24,381	3,614	-	19,997	63,469
3-01-005-04	376,731	901	435	82,204	402,659
3-01-005-05	491,484	7,168	10	54,013	797,087
3-01-005-99	4,745,552	8,079	68	8,967	57,506
3-01-005		41,908 (15.2%)	513 (0.2%)	392,518 (27.7%)	2,352,431 (80.7%)
3-01-999-99	151,288,357	69,015 (25.0%)	44,054 (13.3%)	518,506 (36.5%)	335,500 (11.5%)
3-01-008	248,813 (100 tons/yr)	343 (0.1%)	55,730 (16.8%)	- (-)	144 (-%)
3-01-033-01	3,000 (gal/yr)	- (-)	- (-)	5,801 (0.4%)	- (-)
3-01-900-99	747 (million cu ft/yr)	4,667 (1.7%)	146 (-)	- (-)	18,850 (0.6%)
Other 3-01	182,696,930	159,870 (57.9%)	228,523 (68.8%)	338,554 (23.9%)	194,503 (6.7%)
Total		276,080 (100%)	332,290 (100%)	1,419,000 (100%)	2,915,200 (100%)

[a] Extracted from Ref. 4-6.

[b] Unless otherwise specified, charge rate units are in tons of product per year.

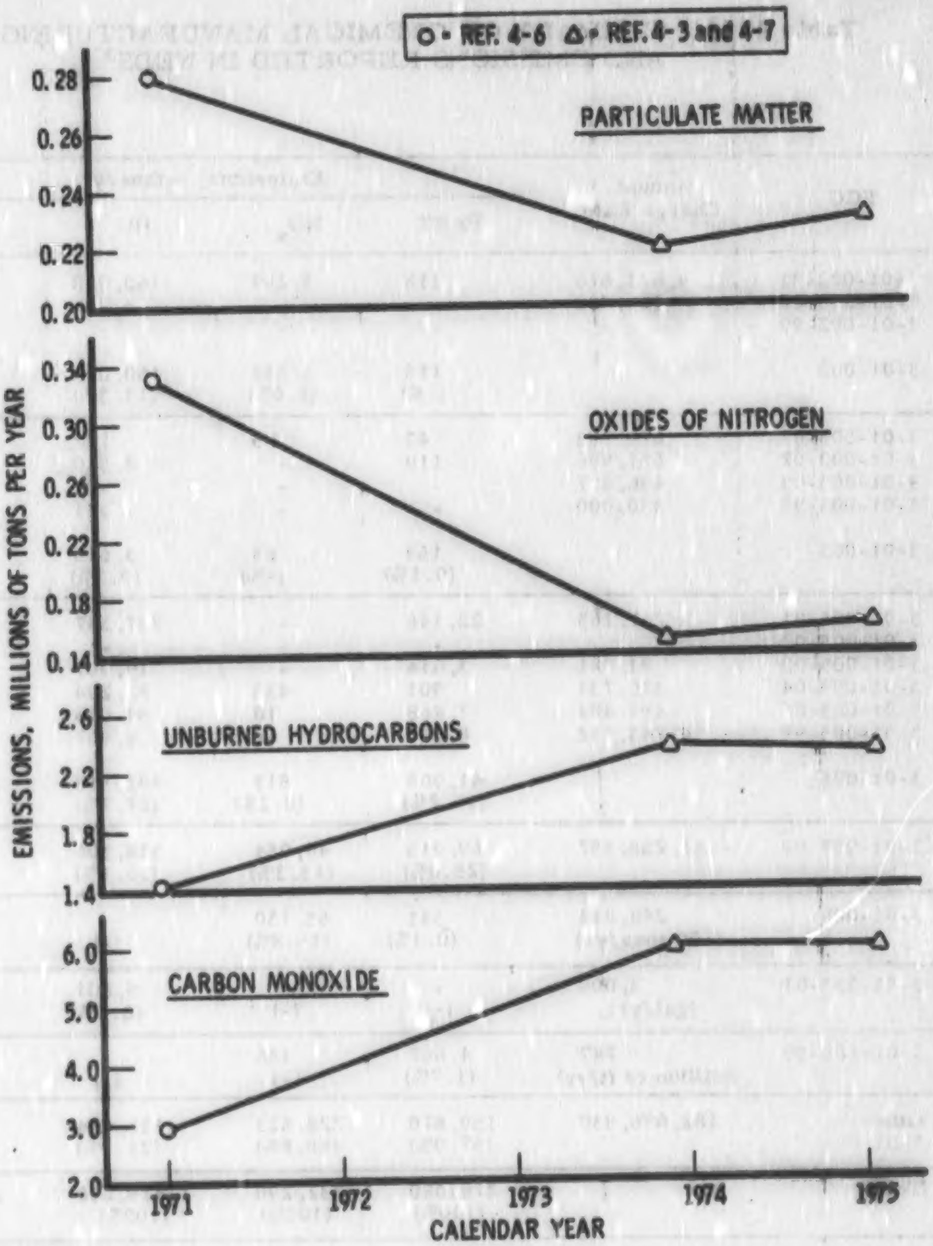

Figure 4-1. Emissions from chemical manufacturing

b. Emissions listed in the summary reports (Refs. 4-3 and 4-7) are based on the product of charge rate and known emission factors. Where the emission factors are not known, zero emissions are entered. This characteristic can only cause the summary report emissions to be low.

4.3.2.2 Lack of Thermal Carbon Black Data

No data were reported under SCC 3-01-005-002 thermal carbon black production. Reference 4-8 shows a steady growth from 47,000 tons in 1950 to 137,000 tons in 1965. Approximately 170,000 tons should have been reported in 1970 according to the trend reported in Ref. 4-8. Total carbon black production in 1970 as extracted from the NEDS falls on the trend line established from Ref. 4-8 only if some production other than that reported in the SCC categories 3-01-005-01, -03, -04, and -05 existed. The difference is close to the forecast production of thermal black in the Ref. 4-8 data. Either thermal carbon black was not reported or it was erroneously reported in SCC 3-01-005-99. Normally, this SCC would be used to report carbon black handling or the manufacturing of some product where carbon black is a principal ingredient. That portion of SCC 3-01-005-99 corresponding to SIC 2895 is close to the deficit. Of the nine SICs comprising SCC 3-01-005-99, SIC 2895 is the only one identified as carbon black.

4.3.3 Ammonia Production

4.3.3.1 Process Description

Two principal methods of ammonia (NH_3) production exist:

a. Methanator process

b. CO absorber process

Both processes combine nitrogen (N) from the atmosphere with hydrogen (H_2) from some HC feed stock such as natural gas. The difference in the two techniques is centered on how the large amounts of CO are handled. The CO results when H_2 is extracted from the HC feed stock. While the CO emissions in the main process of ammonia production are substantially less in the CO absorber technique, the CO efflux from the absorber when it is being rejuvenated tends to be quite high. An extensive water scrubber and incinerator system can considerably reduce the CO emissions during absorber regeneration.

Unburned HC emissions (usually methane) from the purge gas stream are of the same concentration whether the methanator or CO absorber system is used. Scrubbers have a modest effect on HC emissions.

Although beyond the scope of this study, another noteworthy emission is ammonia vapor. This emission can be reduced to almost any level of insignificance through repeated water scrubber application.

4.3.3.2 Data Research and Analysis

Production rates[*] of synthetic ammonia are recorded in Refs. 4-6 and 4-9. The charge rate history is graphically presented in Figure 4-2. Several straight lines were derived by least square fit techniques from various combinations of the data points on Figure 4-2. The straight line obtained when 1964 and 1965 data were excluded yielded the best correlation. Its equation was used when estimating future ammonia production. The uncertainty in baseline production is simply the standard error of estimate obtained with the straight line derivation. The uncertainty of the production slope is the difference in slope for the adopted line and the line derived using the six data points in Figure 4-2. This number is approximately 21 percent of the baseline value.

The total production reflected in Figure 4-2 is considered to be apportioned among the six SCC categories for all years in the same percentage as that listed by the NEDS for the 1970-72 era. Emission factor data are found in three areas:

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[*] The term "production rate" as used here refers to the charge rate associated with the particular operation; e.g., SCC 3-01-002-02 is related to storage and loading, and the ammonia charge rate was actually produced or created under 3-01-002-01 for methanator systems. The production SCC for CO absorption systems is 3-01-003-02.

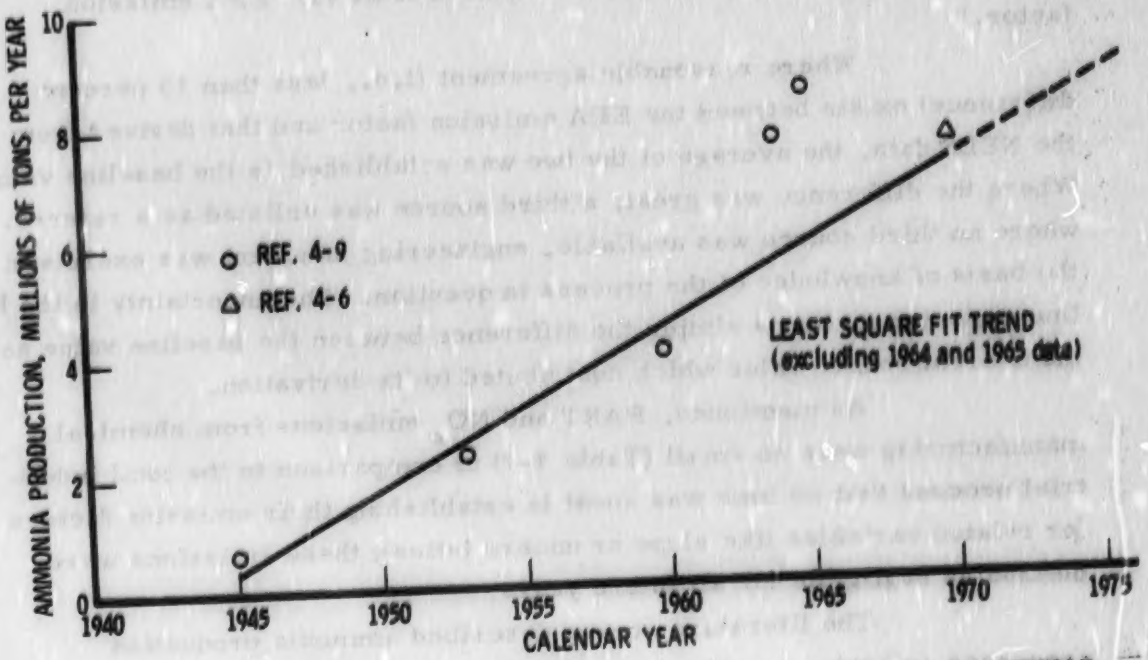

Figure 4-2. Synthetic ammonia production

a. Reference 4-5

b. Reference 4-10

c. Quotient of emissions and charge rate from Ref. 4-6 data.

Where emission factor data exist in Ref. 4-10, they are considered to supersede Ref. 4-5 data. In the following discussion, that which prevails between Refs. 4-5 and 4-10 will be referred to as the "EPA emission factor."

Where reasonable agreement (i.e., less than 15 percent difference) exists between the EPA emission factor and that derived from the NEDS data, the average of the two was established as the baseline value. Where the difference was great, a third source was enlisted as a referee; where no third source was available, engineering judgment was exercised on the basis of knowledge of the process in question. The uncertainty in the baseline emission factor is simply the difference between the baseline value and the nearest source value which contributed to its derivation.

As mentioned, PART and NO_x emissions from chemical manufacturing were so small (Table 4-7) in comparison to the total industrial process that no time was spent in establishing their emission factors (or related variables like slope or uncertainties); these emissions were defined as negligible for all future years.

The literature survey described ammonia production processes as having remained essentially unchanged since 1953, and no substantial changes in controls or process are forecast for the immediate future. As a result, the slope and the slope uncertainties for ammonia emission factors were set to zero.

4.3.3.3 Projections of Ammonia Activity

The total HC emission from ammonia production in 1980 is estimated to be 279,000 tons ± 32,000. The majority (243,000 tons) of these emissions is from methanator-type production. The total estimated CO emissions from ammonia industries in 1980 is 57,000 tons ± 36,000. The NO_x and PART emissions are expected to be negligible in 1980 (as is the case presently) compared to other point source industrial processes emissions.

4.3.4 Carbon Black Industry

4.3.4.1 Processes and Uses

Carbon black is an oil-free ultrafine soot. Although it is used in the paint and printing industry as a pigment, the prominent use is in the rubber industry as a reinforcing agent. Tires, for example, roll three to five times farther with carbon black than without.

Three principal techniques of carbon black production exist:

a. Impingement process
b. Thermal process
c. Furnace process

The furnace process, which accounts for most carbon black production, is subdivided further according to fuel type: oil, natural gas, and oil-enriched natural gas.

The impingement and thermal processes involve incomplete combustion of HC fuel, whereas the thermal process involves thermal decomposition (or cracking) of natural gas by exposing it to heated (2400° to 2800°F) brick work. The impingement process (also called channel process) involves natural gas-fueled flames impinging on surfaces of steel (usually channel cross section) and depositing carbon black. The carbon black is periodically scraped off the channels before pelletizing (to increase the density for more economical shipment) for packaging and shipment. Channel black is one of the finest (20 to 50 nm particle size) grades made. Furnace black particle size is 25 to 160 nm. Although the thermal process produces a much larger particle size (150 to 500 nm) and consequently facilitates control of particulate-type HC emissions, many users of carbon black, such as tire manufacturers, simply cannot use this product. The furnace process employs refractory-lined furnace combustion chambers where the natural gas and oil is burned with insufficient air. The process is continuous in nature, whereas the thermal and impingement processes are cyclic. Furnace reactors have grown to be sophisticated efficient plants compared to the channel black burner houses. The latter are normally temporarily set up at the source of cheap natural gas and involve few controls (except for air flow). Gas furnaces yield 12 to 16 lb of carbon black per 1000 cu ft of gas compared to a yield of 2 to 3 lb/1000 cu ft from the channel black process. The theoretical yield is approximately 32 lb/ 1000 cu ft.

By its nature, carbon black production is a high emitter of HC and CO. Although much of the following practice was implemented to improve efficiency, pollution control benefits are inherent. Since most HC emission are in the form of soot particulate, the most common forms of alleviation are cyclone separators; water scrubbers; bag filters; and, more recently, electrostatic percipitators. Also some consideration has been given to burning HC emissions. This would alleviate the flow of gaseous emissions such as methane as well as the fine particulate soot. CO emissions are left essentially uncontrolled in carbon black production.

4.3.4.2 Data Research and Analysis

4.3.4.2.1 Carbon Black Production

Production rates of carbon black are listed in Ref. 4-8 for selected years from 1925 to 1965. Production rates for 1970 are recorded in Ref. 4-6. With some difficulty, the data from Ref. 4-8 for the years 1950, 1955, 1960, and 1965 were merged with the Ref. 4-6 data to establish a modern-day trend. Two problems were encountered:

a. The Ref. 4-8 furnace data were not broken down by type, i.e., oil, gas, or oil and gas.

b. No production rates were recorded in Ref. 4-6 for thermal black.

Problem a. was disposed of by assuming Ref. 4-8 furnace charge rates were apportioned among the three processes on a percentage basis the same as the Ref. 4-6 data.

The trend of total carbon black production for 1970 follows the same curve as Ref. 4-8 data only if some carbon black production exists other than that reported in Ref. 4-6 under the SCC categories 3-01-005-01, -03, -04, and -05. As seen in Figure 4-3, the deficit closely matches the charge rate reported under SIC 2895 of SCC 3-01-005-99. These observations (plus the fact that corporations listed in the NEDS point source data were involved in other carbon black production) led to defining the 1970 production as the sum of the charge rate for the four previously mentioned SCC categories and the portion of SCC 3-01-005-99 allocated to SIC 2895. Products corresponding to SIC classifications are defined in Ref. 4-1. Figure 4-4 shows the production rate of carbon black for the five processes under these ground rules.

Trend curves were established for the production rate of each process by deriving the least square fit straight line using various combinations of the 1955 to 1970 data. Figure 4-4 shows the curve which used all five sets of data between 1950 and 1970. Even though the 1950-65 data resulted in a better fit (higher correlation coefficient), it was decided to use (for future black production estimates) those curves derived from all five points (1950 to 1970). The rationale was as follows:

a. The inclusion of the latest data (1970) adds credence to future estimates.

b. Use of data from several sources offsets errors in individual data where checking for validity is not possible.

These trend curves were used to establish baseline production in the year 1975. The uncertainty in baseline production is equal to the standard error of estimate obtained in deriving the straight line. The uncertainty of the baseline slope (change in production rate per year) was defined as the difference in slope of straight lines using all five points and that excluding the 1970 data.

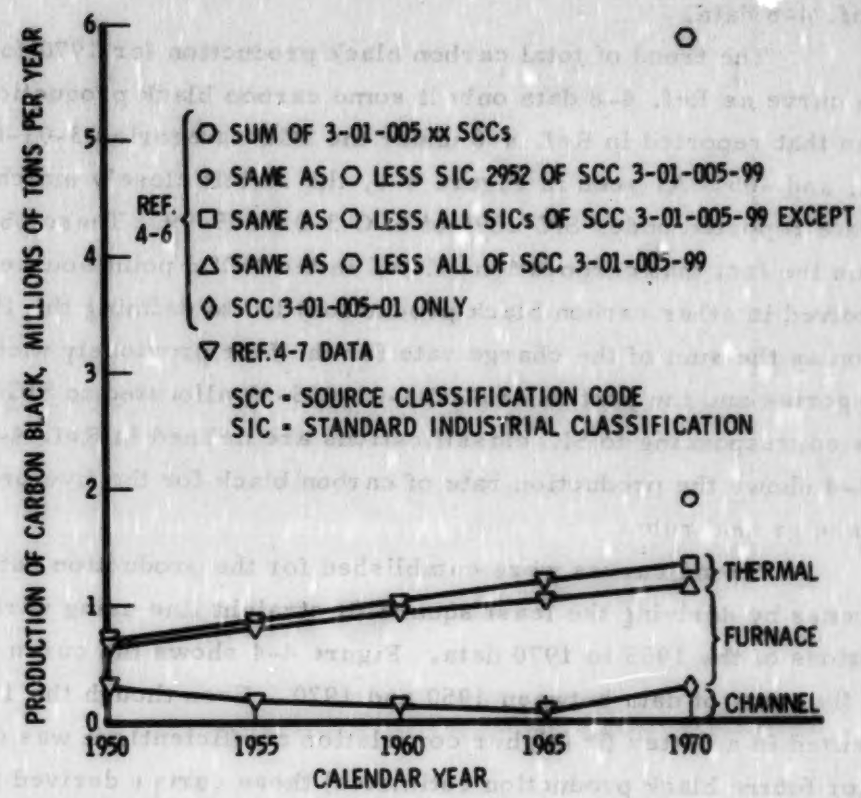

Figure 4-3. Total carbon black production

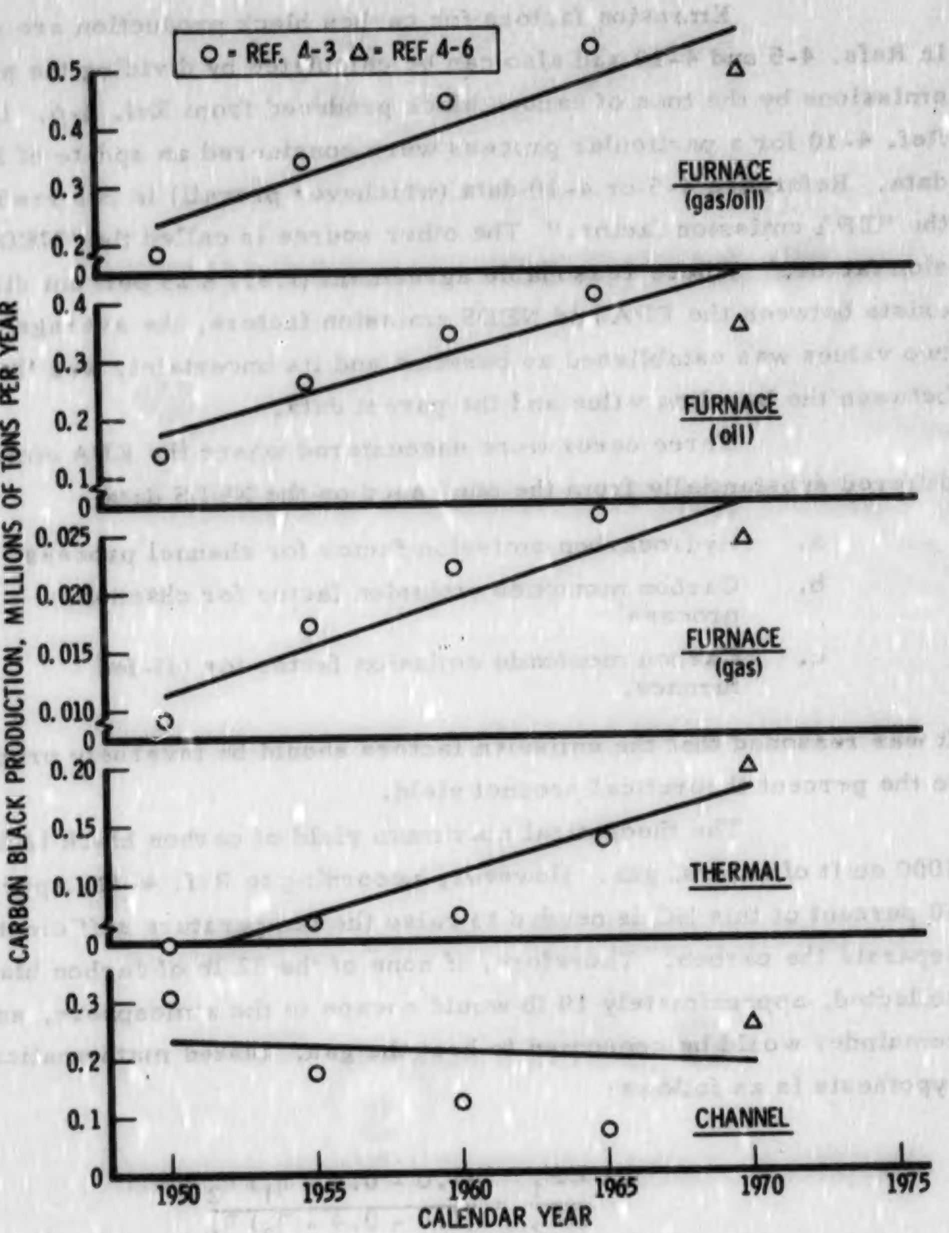

Figure 4-4. Breakdown of carbon black production

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Emission factors for carbon black production are reported in Refs. 4-5 and 4-10 and also can be calculated by dividing the pounds of emissions by the tons of carbon black produced from Ref. 4-6. Data in Ref. 4-10 for a particular process were considered an update of Ref. 4-5 data. Reference 4-5 or 4-10 data (whichever prevail) is referred to as the "EPA emission factor." The other source is called the "NEDS emission factor." Where reasonable agreement (i.e., ≤ 15 percent difference) exists between the EPA and NEDS emission factors, the average of the two values was established as baseline and its uncertainty was the difference between the baseline value and the parent data.

Three cases were encountered where the EPA emission factor differed substantially from the one based on the NEDS data:

a. Hydrocarbon emission factor for channel process

b. Carbon monoxide emission factor for channel process

c. Carbon monoxide emission factor for oil-fed furnace.

It was reasoned that the emission factors should be inversely proportional to the percent theoretical product yield.

The theoretical maximum yield of carbon black is 32 lb/1000 cu ft of natural gas. However, according to Ref. 4-11, approximately 40 percent of this HC is needed to raise the temperature sufficiently to separate the carbon. Therefore, if none of the 32 lb of carbon black were collected, approximately 19 lb would escape to the atmosphere, and the remainder would be consumed to heat the gas. Stated mathematically, the hypothesis is as follows:

$$\frac{EF_1}{EF_2} = \frac{(1.0 - 0.4 - \eta_1)\,\eta_2}{(1.0 - 0.4 - \eta_2)\,\eta_1}$$

where

EF = emission factor

η = decimal fraction of 32 lb that the process yields of carbon black

Since the emission factor for furnace process with gas was known (i.e., good agreement between the EPA emission factor and the one derived from the NEDS), it was used as a basis to establish the three discrepant emission factors. This approach yielded values so close to the ones derived from the NEDS data that the latter was selected for channel baseline emission factors.

In the case of the oil-fired furnace process, the baseline CO emission factor was defined as five percent higher than the one based on NEDS data.

4.3.4.2.2 Miscellaneous Carbon Black Processes

Data were prepared to allow projections to be made in the five MSCC categories of the miscellaneous carbon black industry (MSCC 3-01-005-99). These MSCC categories were based on the SIC classifications listed below and their corresponding products and comprised the point sources under SCC 3-01-005-99 in Ref. 4-6 of the NEDS data:

MSCC	SIC	Product
3-01-005-99-1	2952	Asphalt, felts, and coatings
3-01-005-99-2	3624	Carbon and graphite products
3-01-005-99-3	3999	Manufacturing industries NEC[a]
3-01-005-99-4	2899	Chemical preparation NEC
3-01-005-99-5	3334 3069 3991 2999	Primary aluminum Fabricated rubber products Brooms and brushes Petroleum and coal products

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[a] Not elsewhere classified (NEC).

The baseline charge rate was set equal to the NEDS (1970) value. Uncertainties were set at 5 percent of the base value for categories MSCC 3-01-005-99-1 through 3-01-005-99-4 and to 10 percent for MSCC 3-01-005-99-5, which is a bigger uncertainty since it is comprised of a broad collection of activities. Typical uncertainty of the carbon black production is eight percent.

The baseline emission factors were set equal to the NEDS emissions divided by the charge rate. The emission factor uncertainty was set to 10 percent of baseline value, which was typical of the primary carbon black production SCC categories.

Since little is known about the production and processes in this miscellaneous manufacturing group, no attempt was made to establish a finite slope (trend) or slope uncertainty of any of the data leading to projections of the 3-01-005-99 SCC categories.

4.3.4.3 Projections of Carbon Black Activity

The estimated HC emissions in 1980 carbon black industries are 328,000 tons ± 87,000. Although the channel process is by far the dirtiest (high emission factor), its HC emissions are down both trend-wise and process-wise. The 1980 channel black production is 94,000 tons compared to 116,000 for the oil-fired furnace process. The estimated channel black HC emissions in 1975 are 112,000 tons.

The estimated CO emissions from carbon black in 1980 are 2.37-million tons ± 411,000 tons. The oil-enriched natural gas-fired furnace technique leads CO emissions with 1.17-million tons in 1980.

4.3.5 Miscellaneous Chemical Manufacturing

4.3.5.1 Products

Some 78 separate products (SIC classifications) at 1944 point sources comprised the miscellaneous chemical manufacturing (SCC 3-01-999-99) categories in the NEDS data tape. Entries made under

SIC 2818 and 3999, respectively, constituted approximately 50 percent of the HC and CO emissions. The 76 other SIC products combined represented only 43 percent of the HC and 35 percent CO emissions. Emission projections were made for three subdivisions of miscellaneous chemical manufacturing: (1) SIC 2818, (2) SIC 3999, and (3) remainder (other than SIC 2818 and 3999). SIC 2818 was not defined in Ref. 4-1, but such a classification would be a member of the industrial inorganic chemicals under SIC 281x.

SIC 3999 designates manufacturing industries NEC.

4.3.5.2 Data Definition

The baseline charge rates and emission factors for each category were set equal to the value calculated from the NEDS data (Ref. 4-6). The uncertainties in charge rates and emission factors were based on other chemical manufacturing (ammonia and carbon black).

Slopes and slope uncertainties were set to zero since little is known about the collage of industrial activity.

4.3.5.3 Projections of Miscellaneous Chemical Manufacturing

The estimated 1980 HC and CO emissions from miscellaneous chemical manufacturing are 518,000 ± 65,000 tons and 336,000 ± 129,000 tons, respectively.

4.4 REFERENCES

4-1. Standard Industrial Classification Manual, Executive Branch of The Federal, Government, Statistical Policy Division, Washington, D.C. (1972).

4-2. Guide for Compiling a Comprehensive Emission Inventory, Revised, APTD-1135, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (March 1973).

4-3. NEDS Nationwide Emissions Report as of January 10, 1975 (with New York and West Virginia Supplement), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (February 12, 1975).

4-4. Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (February 1972).

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4-6. "Industrial Processes, Chemical Manufacturing Category," NEDS Data, The Aerospace Corporation Tape Analysis, The Aerospace Corporation, El Segundo, California (February 25, 1975).

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4-10. NEDS Source Classification Codes and Emission Factor Listing (SCC Listing), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (July 1974).

4-11. T. Cox, Jr., "High Quality-High Yield Carbon Black," Chemical Engineering Journal (June 1950).

SECTION V

PETROLEUM REFINERIES

5.1 INTRODUCTION

This section develops data for the petroleum refining industry, in terms of several important source classification codes (SCC), for emissions of particulate (PART) matter, nitrogen oxides (NO_x), unburned hydrocarbons (HC), and carbon monoxide (CO).

The purpose is to provide a general overview of the petroleum refining industry, assess the importance of specific major process sources of atmospheric emissions, estimate current and projected levels, provide the rationale used in making the projections, and present the data sources. Table 5-1 describes the process and charge rate units for each SCC studied.

5.2 SUMMARY

Petroleum industry annual charge rates and emission rates were established for 1975, 1980, 1976, and 1981 and are reported in Tables 5-2-a, 5-3-a, 5-4-a, and 5-5-a, respectively. Uncertainty data are listed in Tables 5-2-b, 5-3-b, 5-4-b, and 5-5-b for 1975, 1980, 1976, and 1981, respectively.

5.3 APPROACH

Developing and forecasting emission inventories requires knowledge or judgment about a combination of factors. Technological generalities are discussed in Section 5.7. Two important elements are total annual charge rates and emission factors. Judgments have been made about expected changes in these parameters resulting from technology advancements,

(Continued on page 5-15)

Table 5-1. DEFINITION OF PETROLEUM INDUSTRY PROCESSES

MSCC	Source Category	Charge Rate Unit
306001010	Process heater (oil-fired, major quantities)	1000 bbl burned/yr
306001020	Process heater (gas-fired, minor quantities)	1000 cu ft burned/yr
306001030	Process heater (oil-fired, minor quantities)	1000 gal burned/yr
306001040	Process heater (gas-fired, major quantities)	Million cu ft burned/yr
306002010	Fluid catalytic cracking	1000 bbl fresh feed/yr
306003010	Moving bed catalytic cracking	
306008010	Miscellaneous leakage (pipe, valve, flange)	1000 bbl refined/yr
306008020	Miscellaneous leakage (vessel relief valves)	1000 bbl refined/yr
306008030	Miscellaneous leakage (pump seals)	1000 bbl refined/yr
306008040	Miscellaneous leakage (compressor seals)	1000 bbl refined/yr
306008050	Miscellaneous leakage (other, general)	1000 bbl refined/yr
306012010	Fluid coking	1000 bbl fresh feed/yr

Table 5-2-a. 1975 PETROLEUM INDUSTRY EMISSIONS AND CHARGE RATES

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1975 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SEC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
306001000		.507	.045	.034	.095
306001010	160600.	.233	.011	.014	.067
306001020	2200000000.	[illegible]	.033	.019	.022
306001030	584700.	.020	.001	.001	.006
306001040	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
306002000	1500000.	.050	.170	16.000	.180
306002010	1500000.	.050	.170	16.000	.180
306003000	108500.	NEGLIGIBLE	.005	.210	NEGLIGIBLE
306003010	108500.	NEGLIGIBLE	.005	.210	NEGLIGIBLE
306008000	26250000.	NEGLIGIBLE	.187	NEGLIGIBLE	NEGLIGIBLE
306008010	5250000.	NEGLIGIBLE	.076	NEGLIGIBLE	NEGLIGIBLE
306008020	5250000.	NEGLIGIBLE	.029	NEGLIGIBLE	NEGLIGIBLE
306008030	5250000.	NEGLIGIBLE	.043	NEGLIGIBLE	NEGLIGIBLE
306008040	5250000.	NEGLIGIBLE	.013	NEGLIGIBLE	NEGLIGIBLE
306008050	5250000.	NEGLIGIBLE	.026	NEGLIGIBLE	NEGLIGIBLE
306012000	110000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.027
306012010	110000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.027

Table 5-2-b. 1975 PETROLEUM INDUSTRY UNCERTAINTIES

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                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                  PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX             HC             CO            PART
306001000                          + .025         + .006         + .005         + .005
                                   - .025         - .006         - .005         - .005

306001010      +        8000.      + .016         + .006         + .003         + .005
               -        8000.      - .016         - .006         - .003         - .005
306001020      +   110000000.      + .018         + .002         + .004         + .002
               -   110000000.      - .018         - .002         - .004         - .002
306001030      +       29000.      + .007         + .000         + .000         + .002
               -       29000.      - .007         - .000         - .000         - .002
306001040          NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE
                   NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE

306002000      +       30000.      + .003         + .009        + 5.890         + .010
               -       30000.      - .003         - .009        - 5.890         - .010

306002010      +       30000.      + .003         + .009        + 5.890         + .010
               -       30000.      - .003         - .009        - 5.890         - .010

306003000      +        2169.     NEGLIGIBLE      + .000         + .011        NEGLIGIBLE
               -        2169.     NEGLIGIBLE      - .000         - .011        NEGLIGIBLE

306003010      +        2169.     NEGLIGIBLE      + .000         + .011        NEGLIGIBLE
               -        2169.     NEGLIGIBLE      - .000         - .011        NEGLIGIBLE

306008000      +      234790.     NEGLIGIBLE      + .034        NEGLIGIBLE     NEGLIGIBLE
               -      234790.     NEGLIGIBLE      - .034        NEGLIGIBLE     NEGLIGIBLE

306008010      +      105000.     NEGLIGIBLE      + .026        NEGLIGIBLE     NEGLIGIBLE
               -      105000.     NEGLIGIBLE      - .026        NEGLIGIBLE     NEGLIGIBLE
306008020      +      105000.     NEGLIGIBLE      + .010        NEGLIGIBLE     NEGLIGIBLE
               -      105000.     NEGLIGIBLE      - .010        NEGLIGIBLE     NEGLIGIBLE
306008030      +      105000.     NEGLIGIBLE      + .016        NEGLIGIBLE     NEGLIGIBLE
               -      105000.     NEGLIGIBLE      - .016        NEGLIGIBLE     NEGLIGIBLE
306008040      +      105000.     NEGLIGIBLE      + .005        NEGLIGIBLE     NEGLIGIBLE
               -      105000.     NEGLIGIBLE      - .005        NEGLIGIBLE     NEGLIGIBLE
306008050      +      105000.     NEGLIGIBLE      + .009        NEGLIGIBLE     NEGLIGIBLE
               -      105000.     NEGLIGIBLE      - .009        NEGLIGIBLE     NEGLIGIBLE
```

Table 5-2-b. 1975 PETROLEUM INDUSTRY UNCERTAINTIES (Continued)

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                 INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1975      RUN DATE= MAR 22,1977
 MODIFIED          TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)        NOX          HC           CO          PART

306012000   +       2199.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   +  .002
            -       2199.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   -  .002

306012010   +       2199.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   +  .002
            -       2199.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE   -  .002
```

Table 5-3-a. 1980 PETROLEUM INDUSTRY EMISSIONS AND CHARGE RATES

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                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS               PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1980     RUN DATE= MAR 22,1977
 MODIFIED         TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)         NOX            HC            CO          PART

306001000                          .326          .055          .038          .082

306001010            112410.       .082          .008          .010          .047
306001020        3100000000.       .234          .047          .027          .031
306001030            586700.       .010          .001          .001          .004
306001040        NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE

306002000           1690000.       .056          .180        11.441          .128

306002010           1690000.       .056          .180        11.441          .128

306003000             70000.   NEGLIGIBLE        .003          .130      NEGLIGIBLE

306003010             70000.   NEGLIGIBLE        .003          .130      NEGLIGIBLE

306008000          29850000.   NEGLIGIBLE        .215      NEGLIGIBLE    NEGLIGIBLE

306008010           6150000.   NEGLIGIBLE        .087      NEGLIGIBLE    NEGLIGIBLE
306008020           6150000.   NEGLIGIBLE        .033      NEGLIGIBLE    NEGLIGIBLE
306008030           6150000.   NEGLIGIBLE        .052      NEGLIGIBLE    NEGLIGIBLE
306008040           9250000.   NEGLIGIBLE        .013      NEGLIGIBLE    NEGLIGIBLE
306008050           6150000.   NEGLIGIBLE        .030      NEGLIGIBLE    NEGLIGIBLE

306012000            120000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE        .029

306012010            120000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE        .029
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Table 5-3-b. 1980 PETROLEUM INDUSTRY UNCERTAINTIES

```
                    INDUSTRIAL  PROCESS, PETROLEUM PRODUCTS             PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980      RUN DATE= MAR 22,1977
 MODIFIED           TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)        NOX              HC             CO          PART

306001000                         +  .032        +  .006        +  .006       +  .006
                                  -  .032        -  .007        -  .006       -  .006

306001010      +        11243.    +  .012        +  .004        +  .002       +  .005
               -        11243.    -  .012        -  .004        -  .002       -  .005
306001020      +    310160000.    +  .030        +  .005        +  .006       +  .003
               -    310160000.    -  .030        -  .005        -  .006       -  .003
306001030      +        58668.    +  .007        +  .000        +  .000       +  .001
               -        58668.    -  .007        -  .000        -  .000       -  .001
306001040          NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE
                   NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE

306002000      +       168980.    +  .006        +  .020        + 6.723       +  .014
               -       168980.    -  .006        -  .020        - 6.723       -  .014

306002010      +       168980.    +  .006        +  .020        + 6.723       +  .014
               -       168980.    -  .006        -  .020        - 6.723       -  .014

306003000      +        21002.    NEGLIGIBLE     +  .001        +  .040       NEGLIGIBLE
               -        21002.    NEGLIGIBLE     -  .001        -  .040       NEGLIGIBLE

306003010      +        21002.    NEGLIGIBLE     +  .001        +  .040       NEGLIGIBLE
               -        21002.    NEGLIGIBLE     -  .001        -  .040       NEGLIGIBLE

306008000      +      1375200.    NEGLIGIBLE     +  .041        NEGLIGIBLE    NEGLIGIBLE
               -      1375200.    NEGLIGIBLE     -  .041        NEGLIGIBLE    NEGLIGIBLE

306008010      +       615030.    NEGLIGIBLE     +  .031        NEGLIGIBLE    NEGLIGIBLE
               -       615030.    NEGLIGIBLE     -  .032        NEGLIGIBLE    NEGLIGIBLE
306008020      +       615030.    NEGLIGIBLE     +  .012        NEGLIGIBLE    NEGLIGIBLE
               -       615030.    NEGLIGIBLE     -  .012        NEGLIGIBLE    NEGLIGIBLE
306008030      +       615030.    NEGLIGIBLE     +  .019        NEGLIGIBLE    NEGLIGIBLE
               -       615030.    NEGLIGIBLE     -  .019        NEGLIGIBLE    NEGLIGIBLE
306008040      +       615030.    NEGLIGIBLE     +  .005        NEGLIGIBLE    NEGLIGIBLE
               -       615030.    NEGLIGIBLE     -  .005        NEGLIGIBLE    NEGLIGIBLE
306008050      +       615030.    NEGLIGIBLE     +  .011        NEGLIGIBLE    NEGLIGIBLE
               -       615030.    NEGLIGIBLE     -  .011        NEGLIGIBLE    NEGLIGIBLE
```

Table 5-3-b. 1980 PETROLEUM INDUSTRY UNCERTAINTIES (Continued)

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                    INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                   PAGE  2
 TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1980      RUN DATE= MAR 22,1977
  MODIFIED          TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC          (SCC UNITS)         NOX          HC            CO            PART

 306012000    +     11998.       NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     +  .004
              -     11998.       NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     -  .004

 306012010    +     11998.       NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     +  .004
              -     11998.       NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE     -  .004
```

Table 5-4-a. 1976 PETROLEUM INDUSTRY EMISSIONS AND CHARGE RATES

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	NOX	HC	CO	PART
		EMISSIONS (MILLIONS OF TONS / YEAR)			
306001000		.471	.047	.035	.092
306001010	150960.	.197	.010	.013	.063
306001020	2380000000.	.256	.036	.021	.024
306001030	586700.	.018	.001	.001	.006
306001040	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
306002000	1538000.	.051	.172	15.863	.171
306002010	1538000.	.051	.172	15.863	.171
306003000	100800.	NEGLIGIBLE	.005	.194	NEGLIGIBLE
306003010	100800.	NEGLIGIBLE	.005	.194	NEGLIGIBLE
306008000	26970000.	NEGLIGIBLE	.193	NEGLIGIBLE	NEGLIGIBLE
306008010	5430000.	NEGLIGIBLE	.077	NEGLIGIBLE	NEGLIGIBLE
306008020	5430000.	NEGLIGIBLE	.030	NEGLIGIBLE	NEGLIGIBLE
306008030	5430000.	NEGLIGIBLE	.046	NEGLIGIBLE	NEGLIGIBLE
306008040	5250000.	NEGLIGIBLE	.013	NEGLIGIBLE	NEGLIGIBLE
306008050	5430000.	NEGLIGIBLE	.027	NEGLIGIBLE	NEGLIGIBLE
306012000	112000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.027
306012010	112000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.027

Table 5-4-b. 1976 PETROLEUM INDUSTRY UNCERTAINTIES

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)			
			NOX	HC	CO	PART
306001000			+ .026	+ .006	+ .005	+ .005
			- .026	- .006	- .005	- .005
306001010	+	8154.	+ .015	+ .005	+ .003	+ .005
	-	8154.	- .015	- .005	- .003	- .005
306001020	+	124350000.	+ .019	+ .003	+ .004	+ .002
	-	124350000.	- .019	- .003	- .004	- .002
306001030	+	30741.	+ .007	+ .000	+ .000	+ .002
	-	30741.	- .007	- .000	- .000	- .002
306001040		NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
		NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
306002000	+	44790.	+ .003	+ .010	+ 6.047	+ .010
	-	44790.	- .003	- .010	- 6.047	- .010
306002010	+	44790.	+ .003	+ .010	+ 6.047	+ .010
	-	44790.	- .003	- .010	- 6.047	- .010
306003000	+	4707.	NEGLIGIBLE	+ .000	+ .013	NEGLIGIBLE
	-	4707.	NEGLIGIBLE	- .000	- .013	NEGLIGIBLE
306003010	+	4707.	NEGLIGIBLE	+ .000	+ .013	NEGLIGIBLE
	-	4707.	NEGLIGIBLE	- .000	- .013	NEGLIGIBLE
306008000	+	358570.	NEGLIGIBLE	+ .035	NEGLIGIBLE	NEGLIGIBLE
	-	358570.	NEGLIGIBLE	- .035	NEGLIGIBLE	NEGLIGIBLE
306008010	+	160360.	NEGLIGIBLE	+ .027	NEGLIGIBLE	NEGLIGIBLE
	-	160360.	NEGLIGIBLE	- .027	NEGLIGIBLE	NEGLIGIBLE
306008020	+	160360.	NEGLIGIBLE	+ .011	NEGLIGIBLE	NEGLIGIBLE
	-	160360.	NEGLIGIBLE	- .011	NEGLIGIBLE	NEGLIGIBLE
306008030	+	160360.	NEGLIGIBLE	+ .016	NEGLIGIBLE	NEGLIGIBLE
	-	160360.	NEGLIGIBLE	- .016	NEGLIGIBLE	NEGLIGIBLE
306008040	+	160360.	NEGLIGIBLE	+ .005	NEGLIGIBLE	NEGLIGIBLE
	-	160360.	NEGLIGIBLE	- .005	NEGLIGIBLE	NEGLIGIBLE
306008050	+	160360.	NEGLIGIBLE	+ .009	NEGLIGIBLE	NEGLIGIBLE
	-	160360.	NEGLIGIBLE	- .009	NEGLIGIBLE	NEGLIGIBLE

Table 5-4-b. 1976 PETROLEUM INDUSTRY UNCERTAINTIES (Continued)

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

			EMISSIONS (MILLIONS OF TONS / YEAR)				
MODIFIED SCC		TACRP (SCC UNITS)	NOX	HC	CO		PART
306012000	+	3225.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+	.002
	-	3225.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	-	.002
306012010	+	3225.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+	.002
	-	3225.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	-	.002

Table 5-5-a. 1981 PETROLEUM INDUSTRY EMISSIONS AND CHARGE RATES

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                        INDUSTRIAL PROCESS, PETROLEJM PRODUCTS                   PAGE  1
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE- MAR 22,1977
  MODIFIED          TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC          (SCC UNITS)          NOX            HC              CO             PART

306001000                              .290           .058            .039           .079

306001010          102770.             .060           .007            .009           .043
306001020      3280000000.             .221           .049            .028           .033
306001030          586700.             .008           .001            .001           .003
306001040       NEGLIGIBLE       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     NEGLIGIBLE

306002000         1728000.             .058           .182          10.168           .115

306002010         1728000.             .058           .182          10.168           .115

306003000           62300.       NEGLIGIBLE           .003            .115     NEGLIGIBLE

306003010           62300.       NEGLIGIBLE           .003            .115     NEGLIGIBLE

306008000        30570000.       NEGLIGIBLE           .221      NEGLIGIBLE     NEGLIGIBLE

306008010         6330000.       NEGLIGIBLE           .090      NEGLIGIBLE     NEGLIGIBLE
306008020         6330000.       NEGLIGIBLE           .034      NEGLIGIBLE     NEGLIGIBLE
306008030         6330000.       NEGLIGIBLE           .094      NEGLIGIBLE     NEGLIGIBLE
306008040         5250000.       NEGLIGIBLE           .013      NEGLIGIBLE     NEGLIGIBLE
306008050         6330000.       NEGLIGIBLE           .031      NEGLIGIBLE     NEGLIGIBLE

306012000          122000.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE           .030

306012010          122000.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE           .030
```

Table 5-5-b. 1981 PETROLEUM INDUSTRY UNCERTAINTIES

INDUSTRIAL PROCESS, PETROLEUM PRODUCTS PAGE 1

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
306001000		+ .034	+ .007	+ .007	+ .007
		- .034	- .007	- .007	- .007
306001010	+ 12404.	+ .010	+ .003	+ .002	+ .006
	- 12404.	- .010	- .004	- .002	- .006
306001020	+ 364970000.	+ .031	+ .006	+ .007	+ .004
	- 364970000.	- .031	- .006	- .007	- .004
306001030	+ 67723.	+ .007	+ .000	+ .000	+ .001
	- 67723.	- .007	- .000	- .000	- .001
306001040	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
306002000	+ 201800.	+ .007	+ .023	+ 6.877	+ .015
	- 201800.	- .007	- .023	- 6.877	- .015
306002010	+ 201800.	+ .007	+ .023	+ 6.877	+ .015
	- 201800.	- .007	- .023	- 6.877	- .015
306003000	+ 25161.	NEGLIGIBLE	+ .001	+ .047	NEGLIGIBLE
	- 25161.	NEGLIGIBLE	- .001	- .047	NEGLIGIBLE
306003010	+ 25161.	NEGLIGIBLE	+ .001	+ .047	NEGLIGIBLE
	- 25161.	NEGLIGIBLE	- .001	- .047	NEGLIGIBLE
306008000	+ 1642900.	NEGLIGIBLE	+ .043	NEGLIGIBLE	NEGLIGIBLE
	- 1642900.	NEGLIGIBLE	- .043	NEGLIGIBLE	NEGLIGIBLE
306008010	+ 734740.	NEGLIGIBLE	+ .033	NEGLIGIBLE	NEGLIGIBLE
	- 734740.	NEGLIGIBLE	- .033	NEGLIGIBLE	NEGLIGIBLE
306008020	+ 734740.	NEGLIGIBLE	+ .013	NEGLIGIBLE	NEGLIGIBLE
	- 734740.	NEGLIGIBLE	- .013	NEGLIGIBLE	NEGLIGIBLE
306008030	+ 734740.	NEGLIGIBLE	+ .020	NEGLIGIBLE	NEGLIGIBLE
	- 734740.	NEGLIGIBLE	- .020	NEGLIGIBLE	NEGLIGIBLE
306008040	+ 734740.	NEGLIGIBLE	+ .005	NEGLIGIBLE	NEGLIGIBLE
	- 734740.	NEGLIGIBLE	- .005	NEGLIGIBLE	NEGLIGIBLE
306008050	+ 734740.	NEGLIGIBLE	+ .012	NEGLIGIBLE	NEGLIGIBLE
	- 734740.	NEGLIGIBLE	- .012	NEGLIGIBLE	NEGLIGIBLE

Table 5-5-b. 1981 PETROLEUM INDUSTRY UNCERTAINTIES (Continued)

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                               INDUSTRIAL PROCESS, PETROLEUM PRODUCTS                  PAGE  2
                                                                          RUN DATE= MAR 22,1977
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981
                                             EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED           TACRP                                                              PART
   SCC          (SCC UNITS)        NOX           HC           CO
                                NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE              +  .004
306012000    +      14323.      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE              -  .004
             -      14323.
                                NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE              +  .004
306012010    +      14323.      NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE              -  .004
             -      14323.
```

regulatory impacts, economic considerations, and other matters. Development of emission factors for the more important SCCs was primarily based upon data provided in Ref. 5-1. The major sources of petroleum refinery emissions stem from combustion-generated emissions resulting from process heating and catalyst regeneration, while HC discharges result mainly from sources of leakage or evaporation.

In certain instances, revisions of CO factors were made for consistency with other firing equipment using similar fuels or known data. For example, the CO emission factor for oil-fired process heaters in SCC 3-06-001-01 is indicated as zero. The corresponding CO emission factor for external combustion boilers (SCC 1-02-004-xx and 1-02-005-xx) indicates 4-lb CO/1000 gal burned, which is equivalent to 168 lb/1000 bbl. The factor used in this instance was accordingly taken as 170 for equipment in this SCC.

In a similar way, it can be determined that CO variation in fluid catalytic cracking introduces uncertainty in the emission factor for SCC 3-06-002-01. The factor given for this effluent in Ref. 5-1 is 13,700-lb CO/SCC. Coke formation ranges between 4 and 10 percent of fresh feed charge. The amount of CO produced varies with the stoichiometry within the regenerator, but a range may be assessed in a simple way by assuming that the CO_2/CO ratio in the off gases is 1.5, which is typical (Ref. 5-2). On the basis of an 8 percent coke formation and a feed gravity of 300 lb/bbl, we have

$$5C + 4O_2 = 2CO + 3CO_2$$

$$\frac{\text{8-lb coke}}{\text{100-lb fresh feed}} \times \frac{\text{56-lb CO}}{\text{60-lb coke}} \times \frac{\text{300 lb}}{\text{bbl}} \times \frac{\text{1000 bbl}}{\text{SCC}} = \text{22,400-lb CO/SCC}$$

Slightly different assumptions can be made to show even more severe emission factors, which merely makes the uncertainty range greater.

5.4 GENERAL REFINERY STATISTICS

Statistical data from several sources served as the basis for obtaining detailed information concerning crude charging rates, production capacities, product yields, and past production trends. Most refiners try to maximize gasoline and fuel production, although some operators concentrate on other specialty products as well. Average yields and other statistics of U.S. refineries are periodically published by the American Petroleum Institute (API) and also in industry journals such as The Oil and Gas Journal (Ref. 5-3). Percentage yields of various petroleum products for 1973 are represented in Table 5-6. As shown, gasoline represents the major product of the industry; the yield of gasoline relative to crude input is nearly one-half the total volume. This is a composite statistic; some refiners can obtain gasoline yields in excess of 60 percent.

Petroleum refinery statistics dating back to 1956 are given in Ref. 5-2. Few changes in refinery yields have occurred. Average gasoline yields have increased from 43.4 to 45.6 percent. The annual growth rate in crude runs to stills for the entire time period of Ref. 5-2 is 2.7 percent and 3.6 percent over the last 10 years. Gasoline production growth over this same time period has been nearly 4 percent and approximately 3 percent over the entire time period. Thus, refiners have been concentrating their efforts on producing ever increasing amounts of gasoline from crude. The most recent estimates for gasoline production in 1974 is about 6.5×10^6 bbl/day or nearly 10^{11} gal/year. Although kerosene production in Ref. 5-4 appears to have declined, it has been replaced by jet fuels. Total kerosenes therefore, are increased. A considerable decline in residual fuel oil yield from 14.7 percent in 1956 to 7.7 percent in 1973 is indicative of further processing of these "heavy ends."

Recent data on a state-by-state basis show that in early 1974 there were 247 refineries operating in the United States, with a daily stream crude capacity of 14.9×10^6 bbl/day, running at 96 percent capacity (Ref. 5-3). For 1975, the daily runs were estimated at 15×10^6 bbl, which when annualized on 350 days results in 5.25×10^9 bbl. Although this appears to be an

Table 5-6. 1973 DISTRIBUTION OF PETROLEUM PRODUCTS

Product	Percent of Refinery Yield
Gasoline	45.61
Distillate Fuel Oil	22.46
Residual Fuel Oil	7.74
Jet Fuel (Kerosene)	5.41
Kerosene	1.73
Jet Fuel (Naphtha)	1.44
Lubricants	1.50
Other	14.11

exceptional rise in the two-year interim following the last tabulated values of Ref. 5-2, it seems in line with present market demand patterns and industry construction.

A number of reference sources can be cited in forecasting energy demands, sources of supply, or projected growth rate of U.S. consumption (Refs. 5-5 through 5-11). Such issues as economics and industrial activity, population growth, domestic government policies, and related international politics lead to considerable uncertainty in forecasts. In this study, considering an overall oil requirement in the vicinity of 22 to 23 million bbl/day by 1980, refinery runs have been estimated to be in the range of 17 to 18.5 million bbl/day. On an annual charge rate basis, the values are from 6.0×10^9 to 6.3×10^9 bbl/year. When a SCC is measured in terms of 1000 bbl/year, these figures represent projected levels of 6.0 to 6.3×10^6 SCC/year and compare favorably with the long-term and recent-term trends discussed earlier.

5.5 PETROLEUM REFINERY PROCESSES EVALUATED

5.5.1 Process Heaters

Energy consumption requirements of typical refineries were determined to establish the emissions from combustion equipment. Energy used in refining, as in other industrial practices, is governed by fuel price. Nelson (Ref. 5-12) has shown that, for an average refinery, net energy consumption varies with refinery complexity, but for many years has generally remained in the range of 10 to 12 percent of processed crude. Newer refineries tend to have lower energy consumption because refiners have installed more efficient systems, enabling better overall heat utilization. In this study, the net energy consumption level was therefore assumed as 10 percent of 0.63×10^6 Btu/bbl oil processed. About two thirds of this heat is obtained in some plants by the burning of refinery process gases and about one third from the firing of salable liquids or residual fuel (Ref. 5-13). A further breakdown of process heater firing was obtained from a NEDS data tape printout which showed that 92 percent of the oil-fired process heater charge rate is in large heaters (SCC category 3-06-001-01) versus 8 percent in small heaters (SCC 3-06-001-03) (Ref. 5-14).

In forecasting to 1980, it was assumed that refineries will continue to increase in complexity (as they have for many years). There are several reasons why this should occur. A large portion of the industry lacks the capability to process high-sulfur crude oil (Ref. 5-15). Therefore, the industry will develop the flexibility to handle such crudes and at the same time will be upgrading production facilities to meet new environmental demands for pollution control and to produce lead-free and low-lead gasoline products. These factors will tend to be offset by certain energy conservation measures; hence, it was assumed that the energy required to operate refineries in 1980 will still be 10 percent of the total product processed by these refineries.

The overall energy consumed by oil-fired heaters will tend to decline as fuel-firing strategies will tend toward selection and use of process gaseous fuels having a low sulfur content. This is dictated by recently promulgated regulations (Refs. 5-16 and 5-17) which limit atmospheric sulfuric oxide (SO_2) emissions from process heaters. It has been estimated that a reduction of up to 30 percent of current energy values in SCC 3-06-001-01 can be realized. The implication of this is that future needs for process heat from this SCC will consume only about 25 percent of refinery fuel requirements, with greater implementation of refinery-process gas-fired equipment. At the same time, improved firing techniques will enable reductions in NO_x emission factors.

5.5.2 Fluid Catalytic Cracking

The fluid catalytic cracking capacity of an average refinery is about 30 percent of crude capacity, with larger companies tending to have higher fractions (approximately 34 percent) and smaller companies having lower fractions (24 percent)(Ref. 5-15). The largest fluid catalytic cracking plants operate in the range of 120,000 bbl/day, and there are eight plants of this size range (Ref. 5-3). The total annual charge rate of this SCC is presently 1.5×10^9 bbl/year. Over the past few years, the growth trend has been a fairly consistent 2.4 percent annually, so that by 1980 the expected new additions will account for 1.69×10^9 bbl/year, if no perturbations occur. According to Conn (Ref. 5-18), the attributes of fluid catalytic cracking are that fluid crackers (1) may be constructed in very large sizes, (2) are relatively free of mechanical problems, and (3) have proven flexible in operation.

As mentioned, several important advances have taken place in fluid catalytic cracking. These include improved catalysts and improved operating and regeneration techniques (such as riser cracking and two-stage regeneration) resulting in improved capacities and yields (Ref. 5-19), lower coke make, and lower emissions (Ref. 5-20). The rising trend in fluid cracking capacity is expected to continue.

However, the new standards of performance which became effective in 1974 limit the emissions from fluid catalytic crackers (Ref. 5-16). The promulgated standards apply to PART and CO emissions from new or modified catalyst regenerators. Essentially, an operator is prohibited from discharging (1) PART matter in excess of 1 kg/1000 kg (1 lb/1000 lb) of coke burnoff in the catalyst regenerator and (2) gases which contain CO in excess of 0.050 percent by volume (500 parts per million).

Background information contained in Refs. 5-21 and 5-22 shows that compliance with the new standards may be achieved by use of more than one type of control technique. Emissions of CO from fluid cracking regenerators are also discussed in Ref. 5-20.

Since the regulations apply to new plants and existing plants which were modified in a way that increased their emissions, it became necessary to assess the expected degree of modernization which can occur between the present and 1980. In other words, to forecast the emissions one must evaluate the expected rapidity of plant replacement and the fraction of controlled emission production levels which would be in effect by 1980. Information concerning refinery abandonments, replacements, enlargement, and modernization is scarce. As reported by Nelson (Ref. 5-23), a refinery that is to operate profitably must adhere to certain rules:

a. Grow in crude capacity so that the refiner retains his share of the growing market

b. Be constantly repaired and maintained

c. Grow in downstream technology to meet product and quality requirements

d. Grow technologically so that it remains competitive

Thus, not only does crude and downstream capacity increase, but whole process units (e.g., crude, cracking, and reforming) are replaced from time to time so that the larger refinery is not simply an accumulation of small units. It has also been shown that on average a refinery can be kept competitive with respect to crude capacity and downstream facilities by doubling every 12 to 13 years, or at an annual rate of 5.7 percent. In addition, during recent years, nonoperating refineries of major companies have been below 0.4 percent of existing capacity. The approach taken was to assume that these criteria apply also to fluid catalytic cracking, and on this basis an analytical assessment was made on 1980 charge rates.

5.5.3 Moving Bed Cracking

This form of catalytic cracking appears to be of diminishing importance in terms of overall charge rates. Recent trends according to Ref. 5-15 show that daily capacity receded from 0.5×10^6 bbl/day in 1972 to 0.3×10^6 bbl/day in 1975. At this rate of decline (roughly 16 percent annually), the daily charge rate would be about 0.13×10^6 bbl/day, but it is not known how the new regulations will affect refiners plans. The approach used was to assume the decline would continue at approximately half this rate so that by 1980 the daily throughput would be 0.2×10^6 bbl/day. The annual charge rate becomes 0.07×10^9 bbl/year or 0.07×10^6 SCC/year. The uncertainty in charge rate is thus relatively high. The emission factors used were those in Ref. 5-1.

5.5.4 Coking and Miscellaneous Categories

These categories include particulate dispersions resulting from coke making and various other HC losses. No special approach was necessary for SCCs based upon total annual charge rate. For coking, annual charge rates were based on the assumption that two percent of capacity is used in coke making. According to Ref. 5-3, coke capacity of 43,410 tons is obtained from a daily feed capacity of 14.2×10^6 bbl. At 300 lb/bbl, we obtain

$$\frac{43,410 \text{ ton/day}}{14.216 \times 10^6 \text{ bbl/day} \times 300 \text{ lb/bbl} \times \frac{\text{ton}}{2000 \text{ lb}}} \times 100 = 2.0\%$$

5.6 RESULTS AND DISCUSSION

Tables 5-2-a and 5-3-a summarize the results of the inventory studies for process heaters, catalytic cracking, and the miscellaneous categories of fluid coking and equipment leakage.

Emission factor levels are generally found to be declining gradually. This is expected to result from higher monetary values for fuel and more stringent control of emissions through expansion and modernization. The new ruling especially in regard to fluid catalytic cracking is estimated to affect 0.67×10^9 bbl/year of fresh feed charge rates out of a total of 1.69×10^9 bbl/year by 1980. In other words, of the current 1.5×10^9, nearly one third of the total charge will either have been replaced or modernized and will therefore be in compliance.

However, as seen in Tables 5-2-b and 5-3-b, large uncertainties can exist in charge rate data, emissions, and other data. It is therefore necessary to periodically review industry production trends, technology achievements, and consumer demands which can impact the resulting year-to-year data.

It was originally intended to compare emission level results from the NEDS data. However, because of significant discrepancies found in the past, this was not attempted here. The most recent NEDS data error showed that total annual charge rate in fluid catalytic cracking was approximately a factor of 20 too high (Ref. 5-24). This error was acknowledged and corrected in Ref. 5-25.

5.7 PETROLEUM REFINERY PRACTICES

5.7.1 Background

Familiarization with overall refinery technology (Ref. 5-23) is prerequisite to understanding the refinery industry practices which constitute important sources of atmospheric emissions. The raw feedstocks, consisting mainly of crude oil but including, also, natural gas and asphalt, are subjected to thermal or chemical treatments leading to a broad variety of intermediate and finished products.

A single refinery may not produce all petroleum products, even in the most diverse of the major composite refineries. Significant differences occur in chemical composition and physical properties of the crude liquid feedstocks that are available to an individual plant. For example, some crudes are highly amenable to the economical production of lubricants and waxes, whereas others may be less so. The fundamental determinant defining which products will be produced at a given refinery is economics. Economics includes not only such factors as equipment capitalization, operating costs, and product values, but also feedstock costs and variability.

5.7.2 Refinery Processing Overview

It is desirable to recognize certain types of similar refinery processes and operations from a chemical engineering aspect. The more important manufacturing procedures that may be associated with atmospheric emissions are identified as follows:

a. Topping
b. Crude distillation
c. Gasoline stabilization
d. Vacuum flash operation
e. Cracking (thermal and catalytic)
f. Catalytic reforming
g. Hydroprocessing
h. Alkylation
i. Isomerization

Topping

The basic operation in all refineries is atmospheric pressure distillation. This operation, known as topping, represents the first step in the fractionation of crude oil feedstock into various boiling range components such as gasoline, kerosene, distillates, lubricants, and fuels. Crude-oil distillation normally requires preheating the feedstock in a heat exchanger train and/or direct-fired heaters before being fed to the distillation tower units. The overhead stream condensate (raw straight-run gasoline) goes to a stabilizer column for propane-butane removal, yielding stabilized straight-run gasoline for later treatment and octane upgrading. The side streams, which boil at intermediate temperatures, yield naphtha, kerosene, diesel oil, and gas oil. The bottom stream, also called reduced crude, may be vacuum-fractionated for lube manufacture or run (with gas oil) into cracking units for conversion into lower molecular weight products, particularly gasoline.

Cracking

The major forms of cracking are thermal and catalytic processes. At one time during World War II, overall gasoline yield from crude was less than 40 percent, and thermal cracking accounted for more than 20 percent of total gasoline yield from crude. Thermal processes are now mainly used for viscosity breaking (visbreaking) of reduced crudes and for coke production. Catalytic cracking is used mostly with gas oil but may sometimes be used on various fractions, including naphtha and residuals. The process takes one of several forms, depending upon the method of handling the catalyst. Fluidized bed catalytic cracking represents the largest overall capacity in the United States, followed by Thermofor and Houdriflow moving bed processes. Cracking causes decomposition of the higher molecular weight constituents of petroleum, which produces products in lower boiling ranges. These include large amounts of olefinic gases, gasoline, and recycle oil. Coincident with the disintegration mechanisms, coke deposits on the catalyst. The amount and rate of coke formation varies with the type of feed and catalyst, system design, and operating conditions. Generally, the coking laydown ranges between 4 and 10 percent of the fresh feed charge (Ref. 5-23).

Since catalyst activity declines with coke deposition, reactivation is required and is accomplished by periodic burnoff of the coke with air. Modern systems operate continuously by recirculating finely divided catalyst beads between the reactor and the regenerator. Regenerator off gases contain the usual combustion products of HC, but complete combustion of carbon is seldom accomplished during regeneration. Concentrations of CO in the flue gases, therefore, are also variable but generally 8 to 10 percent by volume. Further combustion of these gases in flares or CO boilers may be accomplished to recover heat energy and to minimize emissions. Cyclone separators are the means used to retain the solids in the circulating system. Additional separation equipment in the form of electrostatic precipitators can be used to further recover catalyst fines.

Recent advances have occurred in fluid catalytic cracking, including the use of highly active zeolitic catalysts, higher pressures and temperatures, more efficient equipment, and improved construction materials. Higher equipment capacities, improved conversion and energy utilization, higher octane products, and greater operating flexibility have resulted. Descriptions of several modern catalytic cracking processes as practiced by major refiners are provided in Ref. 5-26. Considerable study effort was devoted to catalytic cracking practices because of the overall impact of these practices on atmospheric emissions.

Catalytic Reforming

Catalytic reforming causes rearrangement of HC molecules, primarily accompanied by hydrogen abstraction (dehydrogenation) or addition (hydrogenation). The process is used to upgrade low-octane naphtha to high-octane gasolines and to produce aromatics such as benzene, toluene, and xylene (BTX). Reforming was developed in the late 1940s and early 1950s with a platinum catalyst on a ceramic substrate. One of the main advantages of the so-called platforming process at that time was the great improvement in catalyst lifetime relative to existing cracking catalysts. In catalytic cracking, about 10-gal oil/lb catalyst could be processed before regeneration was needed while the reforming processes could treat 1000-gal oil/lb catalyst. By 1956, as much as 10,000-gal oil/lb catalyst could be treated. Other advantages of reforming included resistance to permanent catalyst poisoning, ability to achieve multiple reactions simultaneously (e.g., dehydrogenation, dehydroisomerization, dehydrocyclization, isomerization, and hydrodesulfurization). In short, the process was used to produce a high quality gasoline known as reformate and a high yield of aromatics (for which there existed a high market demand at the time). More recently, catalytic reforming processes have become a valuable source of byproduct hydrogen. As in the case of catalytic cracking, newer catalysts (some including nonnoble materials) are being developed. The processes are variously referred to as platforming, magnaforming, houdriforming, powerforming, rheniforming, and ultraforming (Ref. 5-26).

A particular type of reforming process involving rearrangement of a HC molecular structure is known as isomerization. Originally, isomerization involved the vapor-phase conversion of HC from one structure to another by an acid catalyst (e.g., butane to isobutane, C_4 isomerization; pentane to isopentanes, C_5 isomerization). Now, more modern plants such as Butamer, Penex, and Hysomer process reactants in the presence of highly active and selective fixed-bed noble catalysts. Such plants are often operated in conjunction with alkylation facilities. The clear octane ratings of isomerization products is significantly improved. Unconverted reactants are often recycled.

Hydroprocessing

The rapid increase in catalytic reforming capacity during the past 25 years and the consequent availability of large amounts of hydrogen produced therefrom has stimulated the development of refinery processing in which the low-cost hydrogen is consumed or used within a particular process. The general terms hydroprocessing, hydrotreating, and hydrorefining are used to describe a multitude of production systems. The most usual applications are for desulfurization (also called hydrosulfurization) of various petroleum fractions in which many of the more stable sulfur-containing compounds, such as mercaptans, are destroyed catalytically into HC remnants. The liberated sulfur combines with the hydrogen to form hydrogen sulfide gas which requires removal to avoid emission to the atmosphere. This may be accomplished in several ways, often leading to recovery of marketable byproduct sulfur compounds.

Some of the more commonly known processes are Gulfining, HDS, RDS, VRDS, and ultrasweetening. Besides desulfurization treatments, hydrogen processing includes selective hydrogenation treatment of certain olefin or aromatic stocks and lube oil improvement. Finally, there are combination processes such as ultrafining. A number of hydroprocessing plant descriptions are contained in Ref. 5-26.

Rebuilding Processes

Several processes are used to rebuild various types of low molecular weight of hydrocarbons into higher molecular weight species. Alkylation and polymerization are processes in which unsaturated two-, three-, and four-carbon atom gases are reacted in order to form high-octane branched chain hydrocarbons for gasoline. The olefinic feedstocks are usually cuts obtained from catalytic cracking. When olefins are added to olefins, the product is called polymer gasoline. When an olefin is connected to a saturated molecule such as isobutane, the product is called alkylate. Alkylate finds extensive use in aviation gasoline.

Other Processes

Several other refinery processes were examined but do not appear at this time to be significant factors relating to atmospheric emissions in terms of volatile HC, CO, CO_2, or NO_x except, perhaps, from the standpoint of requiring boiler-produced steam or direct-fired thermal energy. These include the following:

a. Light oil treating
b. Lube oil processing

c. Asphalt manufacture
d. Sulfur recovery
e. Wax forming operations

Coking processes involve relatively severe cracking for converting heavy components (such as pitch and tar) into lighter products (such as gas oil and coke) for fuel and other specialty uses. Two major processes are delayed coking and fluid coking, the latter being a continuous fluidized bed circulation flow process. In withdrawing the coke product from the system, some entrainment of particulates does occur as the gases pass through the cyclone separators and disperse to the atmosphere.

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SECTION VI

POINT SOURCE EVAPORATION

6.1 INTRODUCTION

The point source evaporation category of stationary source emissions is comprised of activities involving cleaning solvents, surface coatings, and the storage and marketing transportation of petroleum products. The emissions of concern are hydrocarbons (HC), which are approximately 99 percent of all point source evaporative emissions.

Forty-nine Source Classification Code (SCC) categories were identified from Ref. 6-1 which emitted 500 tons per year or more of pollutant. These point source emission categories formed the list of activities studied in the HC evaporation category. For better identification of the nature of HC emissions from evaporation, many of the 49 SCCs were subdivided to yield a total of 85 processes, which were identified as modified SCCs (MSCC) categories.

6.2 SUMMARY

The total HC evaporation rate from point sources in 1976 was 4.25-million tons/year and is estimated to drop by 40 percent to 2.5-million tons/year in 1981.

The largest contributor to these totals is the paint and surface coating application industries. The most dramatic reduction in estimated emissions between 1976 and 1981 occurs in the petroleum products storage category. The reduction is estimated to be 1.15-million tons/year (1.65 to 0.50) or a minus 70 percent change in the 5-year period. This reduction is based on an assumed elimination of the use of fixed-roof tanks for the storage of the most volatile products (gasoline and crude oil).

Table 6-1 presents the MSCC number, description, and charge rate unit for the point source evaporation categories studied. A detailed list of emissions from evaporation and total annual charge rates (TACRP) is shown in Tables 6-2 and 6-3 for 1976 and 1981, respectively.

6.3 PROCESSES EVALUATED

According to the National Emissions Data System (NEDS) (Ref. 6-2), 4.5-million tons of HC vapor are annually evaporated into the atmosphere from stationary point sources. This represents 58 percent of the total (evaporation plus combustion) point source HC emissions and 40 percent of the total (point plus area) stationary source HC emissions. In addition to the 4.5-million tons/year of HC from point source evaporation, Ref. 6-2 lists another 2.75-million tons/year of HC from area source evaporation. (A point source is identified as more than or equal to 100 tons/year; an area source is less than this amount.) Except for HC evaporation from handling gasoline at retail outlets (filling stations), no consideration was given to area source emissions. This section presents discussions of the processes that produce stationary source HC evaporative emission.

6.3.1 Cleaning Solvents

Cleaning solvents are broadly divided into two application categories: (1) dry cleaning of clothing and (2) degreasing of metal and other parts.

The emissions from cleaning solvents represent only about 3 percent of total point source/evaporation. Petroleum (Stoddard) and chlorinated synthetic (Perchlorethylene) solvents are used for both applications where trichlorethane, trichloroethylene, and methylene chloride are used only for degreasing operations. Although the petroleum-based solvent is considered the most attractive from a low pollution standpoint, because it is not photochemically reactive, its production rate is on the decline. It is

(Continued on page 6-39)

Table 6-1. DEFINITION OF HC EVAPORATION

MSCC	Source Category	Charge Rate Unit
401001010	Perchlorethylene dry cleaning	Clothes, tons/yr
401001020	Stoddard dry cleaning	Clothes, tons/yr
401002010	Stoddard degreasing solvent	Solvent, tons/yr
401002020	Trichleroethane degreasing solvent	Solvent, tons/yr
401002030	Perchloroethylene degreasing solvent	Solvent, tons/yr
401002050	Trichloroethylene degreasing solvent	Solvent, tons/yr
401002990	Miscellaneous degreasing solvent	Solvent, tons/yr
402001011	Sheet, strip, and coil paint	Paint, tons/yr
402001012	Auto and truck paint	Paint, tons/yr
402001013	Major appliances paint	Paint, tons/yr
402001014	Industrial machinery paint	Paint, tons/yr
402001015	Wooden furniture paint	Paint, tons/yr
402001016	Metal furniture paint	Paint, tons/yr
402001017	Small appliances paint	Paint, tons/yr
402001018	Farm machinery paint	Paint, tons/yr
402001019	Commercial machinery paint	Paint, tons/yr
402002011	Coating for coated paper	Coating, tons/yr
402002012	Coating for folding cartons	Coating, tons/yr
402002013	Coating for craft paper	Coating, tons/yr
402002014	Coating for milk cartons	Coating, tons/yr
402002015	Coating for paper bags	Coating, tons/yr
402002016	Coating for paper boxes	Coating, tons/yr
402002017	Coating for paper tubes and cans	Coating, tons/yr
402002018	Coating for printing paper	Coating, tons/yr
402002019	Coating for waxed paper	Coating, tons/yr

Table 6-1. DEFINITION OF HC EVAPORATION (Continued)

MSCC	Source Category	Charge Rate Unit
402003011	Varnish and shellac on sheet, strip, and coil	Coating, tons/yr
402003013	Varnish and shellac on major appliances	Coating, tons/yr
402003014	Varnish and shellac on industrial machinery	Coating, tons/yr
402003017	Varnish and shellac on small appliances	Coating, tons/yr
402003019	Varnish and shellac on commercial machinery	Coating, tons/yr
402004011	Lacquer on sheet, strip, and coil	Coating, tons/yr
402004012	Lacquer on autos and trucks	Coating, tons/yr
402004015	Lacquer on wooden furniture	Coating, tons/yr
402004017	Lacquer on small appliances	Coating, tons/yr
402005011	Enamel on sheet, strip, and coil	Coating, tons/yr
402005012	Enamel on autos and trucks	Coating, tons/yr
402005013	Enamel on major appliances	Coating, tons/yr
402005016	Enamel on metal furniture	Coating, tons/yr
402005017	Enamel on small appliances	Coating, tons/yr
402006011	Primer on sheet, strip, and coil	Coating, tons/yr
402006012	Primer on autos and trucks	Coating, tons/yr
402006014	Primer on industrial machinery	Coating, tons/yr
402006016	Primer on metal furniture	Coating, tons/yr
402006017	Primer on small appliances	Coating, tons/yr
402006019	Primer on commercial furniture	Coating, tons/yr
402007011	Dye for fabric	Solution, tons/yr
402007012	Permanent crispness solution for fabric	Solution, tons/yr
402007013	Sizing solution for fabric	Solution, tons/yr

Table 6-1. DEFINITION OF HC EVAPORATION (Continued)

MSCC	Source Category	Charge Rate Unit
402007014	Waterproof solution for fabric	Solution, tons/yr
402007015	Wrinkle resistance solution for fabric	Solution, tons/yr
402008011	Oven coating for sheet, strip, and coil	Coating, tons/yr
402008012	Oven coating for autos and trucks	Coating, tons/yr
402999990	Miscellaneous surface coating activity	Coating, tons/yr
403001011	Fixed-roof tank gasoline breathing loss	Storage capacity, 1000 gal
403001021	Fixed-roof tank crude breathing loss	Storage capacity, 1000 gal
403001031	Fixed-roof tank gasoline working loss	Throughput, 1000 gal/yr
403001041	Fixed-roof tank crude working loss	Throughput, 1000 gal/yr
403001051	Fixed-roof tank JP-4 breathing loss loss	Storage capacity, 1000 gal
403001061	Fixed-roof tank kerosene breathing loss	Storage capacity, 1000 gal
403001071	Fixed-roof tank distillate breathing loss	Storage capacity, 1000 gal
403001501	Fixed-roof tank JP-4 working loss	Throughput, 1000 gal/yr
403001511	Fixed-roof tank kerosene working loss	Throughput, 1000 gal/yr
403001521	Fixed-roof tank distillate working loss	Throughput, 1000 gal/yr
403002011	Floating-roof gasoline tank standing loss	Storage capacity, 1000 gal
403002021	Floating-roof gasoline tank working loss	Throughput, 1000 gal/yr
403002031	Floating-roof crude tank standing loss	Storage capacity, 1000 gal

Table 6-1. DEFINITION OF HC EVAPORATION (Continued)

MSCC	Source Category	Charge Rate Unit
403002041	Floating-roof crude tank working loss	Throughput, 1000 gal/yr
403002051	Floating-roof JP-4 tank standing loss	Throughput, 1000 gal/yr
403002061	Floating-roof kerosene standing loss	Storage capacity, 1000 gal
403002071	Floating-roof distillate standing loss	Storage capacity, 1000 gal
403003020	Variable vapor-space gasoline working loss	Throughput, 1000 gal/yr
403999990	Miscellaneous petroleum product storage loss	Stored, 1000 gal
406001011	Load gasoline on tank cars, splash	Transferred, 1000 gal/yr
406001012	Load gasoline on tank trucks, splash	Transferred, 1000 gal/yr
406001021	Load crude on tank cars, splash	Transferred,
406001022	Load crude on trucks, splash	Transferred,
406001261	Load gasoline on tank cars, submerge	Transferred, 1000 gal/yr
406001262	Load gasoline on tank trucks, submerge	Transferred, 1000 gal/yr
406001271	Load crude on tank cars, submerge	Transferred, 1000 gal/yr
406002010	Load gasoline onto marine vessels	Transferred,
406002260	Unload gasoline from marine vessels	Transferred, 1000 gal/yr
406002270	Unload crude from marine vessels	Transferred, 1000 gal/yr

Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES

HYDROCARBON EVAPORATION PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
401001000	41850.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
401001010	29420.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
401001020	12430.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
401002000	114460.	NEGLIGIBLE	.103	NEGLIGIBLE	NEGLIGIBLE
401002010	1060.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
401002020	3570.	NEGLIGIBLE	.003	NEGLIGIBLE	NEGLIGIBLE
401002030	7213.	NEGLIGIBLE	.006	NEGLIGIBLE	NEGLIGIBLE
401002050	5170.	NEGLIGIBLE	.005	NEGLIGIBLE	NEGLIGIBLE
401002990	97450.	NEGLIGIBLE	.086	NEGLIGIBLE	NEGLIGIBLE
401999000	115650.	NEGLIGIBLE	.025	NEGLIGIBLE	NEGLIGIBLE
401999990	115650.	NEGLIGIBLE	.025	NEGLIGIBLE	NEGLIGIBLE
402001000	438000.	NEGLIGIBLE	.224	NEGLIGIBLE	NEGLIGIBLE
402001010	438000.	NEGLIGIBLE	.224	NEGLIGIBLE	NEGLIGIBLE
402001011	310000.	NEGLIGIBLE	.174	NEGLIGIBLE	NEGLIGIBLE
402001012	84000.	NEGLIGIBLE	.033	NEGLIGIBLE	NEGLIGIBLE
402001013	10752.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
402001014	7454.	NEGLIGIBLE	.003	NEGLIGIBLE	NEGLIGIBLE
402001015	10704.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
402001016	8168.	NEGLIGIBLE	.003	NEGLIGIBLE	NEGLIGIBLE
402001017	2218.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001018	3272.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001019	1435.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402002000	10136000.	NEGLIGIBLE	.441	NEGLIGIBLE	NEGLIGIBLE
402002010	10136000.	NEGLIGIBLE	.441	NEGLIGIBLE	NEGLIGIBLE
402002011	131720.	NEGLIGIBLE	.061	NEGLIGIBLE	NEGLIGIBLE
402002012	21100.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

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                                  HYDROCARBON EVAPORATION                                    PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976              RUN DATE= MAR 22,1977
 MODIFIED         TACRP                     EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX          HC            CO            PART
402002013        144240.        NEGLIGIBLE      .063       NEGLIGIBLE     NEGLIGIBLE
402002014         27980.        NEGLIGIBLE      .025       NEGLIGIBLE     NEGLIGIBLE
402002015       9328000.        NEGLIGIBLE      .196       NEGLIGIBLE     NEGLIGIBLE
402002016         74480.        NEGLIGIBLE      .014       NEGLIGIBLE     NEGLIGIBLE
402002017          6036.        NEGLIGIBLE      .001       NEGLIGIBLE     NEGLIGIBLE
402002018         77220.        NEGLIGIBLE      .044       NEGLIGIBLE     NEGLIGIBLE
402002019        325400.        NEGLIGIBLE      .033       NEGLIGIBLE     NEGLIGIBLE

402003000        274170.        NEGLIGIBLE      .181       NEGLIGIBLE     NEGLIGIBLE

402003010        274170.        NEGLIGIBLE      .181       NEGLIGIBLE     NEGLIGIBLE

402003011        264000.        NEGLIGIBLE      .174       NEGLIGIBLE     NEGLIGIBLE
402003013          9240.        NEGLIGIBLE      .006       NEGLIGIBLE     NEGLIGIBLE
402003014           498.        NEGLIGIBLE      .000       NEGLIGIBLE     NEGLIGIBLE
402003017           332.        NEGLIGIBLE      .000       NEGLIGIBLE     NEGLIGIBLE
402003019            95.        NEGLIGIBLE      .000       NEGLIGIBLE     NEGLIGIBLE

402004000         75735.        NEGLIGIBLE      .056       NEGLIGIBLE     NEGLIGIBLE

402004010         75735.        NEGLIGIBLE      .056       NEGLIGIBLE     NEGLIGIBLE

402004011         29900.        NEGLIGIBLE      .022       NEGLIGIBLE     NEGLIGIBLE
402004012         41760.        NEGLIGIBLE      .031       NEGLIGIBLE     NEGLIGIBLE
402004015          4022.        NEGLIGIBLE      .003       NEGLIGIBLE     NEGLIGIBLE
402004017            53.        NEGLIGIBLE      .000       NEGLIGIBLE     NEGLIGIBLE

402005000        298340.        NEGLIGIBLE      .172       NEGLIGIBLE     NEGLIGIBLE

402005010        298340.        NEGLIGIBLE      .172       NEGLIGIBLE     NEGLIGIBLE

402005011        118900.        NEGLIGIBLE      .068       NEGLIGIBLE     NEGLIGIBLE
402005012        167040.        NEGLIGIBLE      .095       NEGLIGIBLE     NEGLIGIBLE
402005013         11920.        NEGLIGIBLE      .009       NEGLIGIBLE     NEGLIGIBLE
402005016           240.        NEGLIGIBLE      .000       NEGLIGIBLE     NEGLIGIBLE
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Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
402005017	244.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006000	876030.	NEGLIGIBLE	.467	NEGLIGIBLE	NEGLIGIBLE
402006010	876030.	NEGLIGIBLE	.467	NEGLIGIBLE	NEGLIGIBLE
402006011	850000.	NEGLIGIBLE	.453	NEGLIGIBLE	NEGLIGIBLE
402006012	20880.	NEGLIGIBLE	.011	NEGLIGIBLE	NEGLIGIBLE
402006014	476.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006016	4260.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
402006017	318.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006019	92.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007000	1583700.	NEGLIGIBLE	.229	NEGLIGIBLE	NEGLIGIBLE
402007010	1583700.	NEGLIGIBLE	.229	NEGLIGIBLE	NEGLIGIBLE
402007011	334600.	NEGLIGIBLE	.217	NEGLIGIBLE	NEGLIGIBLE
402007012	270.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007013	1056800.	NEGLIGIBLE	.011	NEGLIGIBLE	NEGLIGIBLE
402007014	10672.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007015	181400.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402008000	170640.	NEGLIGIBLE	.104	NEGLIGIBLE	NEGLIGIBLE
402008010	170640.	NEGLIGIBLE	.104	NEGLIGIBLE	NEGLIGIBLE
402008011	66240.	NEGLIGIBLE	.040	NEGLIGIBLE	NEGLIGIBLE
402008012	104400.	NEGLIGIBLE	.064	NEGLIGIBLE	NEGLIGIBLE
402999000	1500900.	NEGLIGIBLE	.202	NEGLIGIBLE	.010
402999990	1500900.	NEGLIGIBLE	.202	NEGLIGIBLE	.010

Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 4

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	IACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
403001000		NEGLIGIBLE	1.318	NEGLIGIBLE	NEGLIGIBLE
403001010	17100000.	NEGLIGIBLE	.889	NEGLIGIBLE	NEGLIGIBLE
403001011	17100000.	NEGLIGIBLE	.889	NEGLIGIBLE	NEGLIGIBLE
403001020	1480000.	NEGLIGIBLE	.044	NEGLIGIBLE	NEGLIGIBLE
403001021	1480000.	NEGLIGIBLE	.044	NEGLIGIBLE	NEGLIGIBLE
403001030	43000000.	NEGLIGIBLE	.223	NEGLIGIBLE	NEGLIGIBLE
403001031	43000000.	NEGLIGIBLE	.223	NEGLIGIBLE	NEGLIGIBLE
403001040	18400000.	NEGLIGIBLE	.082	NEGLIGIBLE	NEGLIGIBLE
403001041	18400000.	NEGLIGIBLE	.082	NEGLIGIBLE	NEGLIGIBLE
403001050	124000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001051	124000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001060	500000.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
403001061	500000.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
403001070	6909400.	NEGLIGIBLE	.050	NEGLIGIBLE	NEGLIGIBLE
403001071	6909400.	NEGLIGIBLE	.050	NEGLIGIBLE	NEGLIGIBLE
403001500	48450000.	NEGLIGIBLE	.025	NEGLIGIBLE	NEGLIGIBLE
403001501	1570000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001510	20800000.	NEGLIGIBLE	.010	NEGLIGIBLE	NEGLIGIBLE
403001511	20800000.	NEGLIGIBLE	.010	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 5

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
403001520	26080000.	NEGLIGIBLE	.012	NEGLIGIBLE	NEGLIGIBLE
403001521	26080000.	NEGLIGIBLE	.012	NEGLIGIBLE	NEGLIGIBLE
403002000		NEGLIGIBLE	.200	NEGLIGIBLE	NEGLIGIBLE
403002010	7920000.	NEGLIGIBLE	.053	NEGLIGIBLE	NEGLIGIBLE
403002011	7920000.	NEGLIGIBLE	.053	NEGLIGIBLE	NEGLIGIBLE
403002020	9600000.	NEGLIGIBLE	.013	NEGLIGIBLE	NEGLIGIBLE
403002021	9600000.	NEGLIGIBLE	.013	NEGLIGIBLE	NEGLIGIBLE
403002030	10760000.	NEGLIGIBLE	.057	NEGLIGIBLE	NEGLIGIBLE
403002031	10760000.	NEGLIGIBLE	.057	NEGLIGIBLE	NEGLIGIBLE
403002040	48800000.	NEGLIGIBLE	.077	NEGLIGIBLE	NEGLIGIBLE
403002041	48800000.	NEGLIGIBLE	.077	NEGLIGIBLE	NEGLIGIBLE
403002050	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002051	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002060	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002061	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002070	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002071	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403003000	14860000.	NEGLIGIBLE	.065	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-a. 1976 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

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                                HYDROCARBON EVAPORATION                          PAGE  6
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976    RUN DATE= MAR 22,1977
 MODIFIED         TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)           NOX          HC         CO           PART
403003020      14860000.      NEGLIGIBLE      .065     NEGLIGIBLE   NEGLIGIBLE
403999000      15000000.      NEGLIGIBLE      .069     NEGLIGIBLE   NEGLIGIBLE
403999990      15000000.      NEGLIGIBLE      .069     NEGLIGIBLE   NEGLIGIBLE
406001000      81932000.      NEGLIGIBLE      .237     NEGLIGIBLE   NEGLIGIBLE
406001010      22996000.      NEGLIGIBLE      .143     NEGLIGIBLE   NEGLIGIBLE
406001011         96000.      NEGLIGIBLE      .001     NEGLIGIBLE   NEGLIGIBLE
406001012      22900000.      NEGLIGIBLE      .142     NEGLIGIBLE   NEGLIGIBLE
406001020       2581000.      NEGLIGIBLE      .014     NEGLIGIBLE   NEGLIGIBLE
406001021         65000.      NEGLIGIBLE      .000     NEGLIGIBLE   NEGLIGIBLE
406001022       2516000.      NEGLIGIBLE      .013     NEGLIGIBLE   NEGLIGIBLE
406001260      43604000.      NEGLIGIBLE      .063     NEGLIGIBLE   NEGLIGIBLE
406001261        104000.      NEGLIGIBLE      .000     NEGLIGIBLE   NEGLIGIBLE
406001262      43500000.      NEGLIGIBLE      .062     NEGLIGIBLE   NEGLIGIBLE
406001270      12751000.      NEGLIGIBLE      .018     NEGLIGIBLE   NEGLIGIBLE
406001271        351000.      NEGLIGIBLE      .000     NEGLIGIBLE   NEGLIGIBLE
406001272      12400000.      NEGLIGIBLE      .017     NEGLIGIBLE   NEGLIGIBLE
406002000     118600000.      NEGLIGIBLE      .141     NEGLIGIBLE   NEGLIGIBLE
406002010      21300000.      NEGLIGIBLE      .021     NEGLIGIBLE   NEGLIGIBLE
406002020      12000000.      NEGLIGIBLE      .010     NEGLIGIBLE   NEGLIGIBLE
406002260      21300000.      NEGLIGIBLE      .017     NEGLIGIBLE   NEGLIGIBLE
406002270      64000000.      NEGLIGIBLE      .093     NEGLIGIBLE   NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES

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                              HYDROCARBON EVAPORATION                                   PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976                      RUN DATE= MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED          TACRP                                    HC             CO             PART
   SCC         (SCC UNITS)          NOX
401001000   +      23358.        NEGLIGIBLE       +  .004        NEGLIGIBLE      NEGLIGIBLE
            -      15367.        NEGLIGIBLE       -  .002        NEGLIGIBLE      NEGLIGIBLE

401001010   +       9035.        NEGLIGIBLE       +  .001        NEGLIGIBLE      NEGLIGIBLE
            -       9035.        NEGLIGIBLE       -  .001        NEGLIGIBLE      NEGLIGIBLE
401001020   +      21540.        NEGLIGIBLE       +  .003        NEGLIGIBLE      NEGLIGIBLE
            -      12430.        NEGLIGIBLE       -  .002        NEGLIGIBLE      NEGLIGIBLE

401002000   +      51063.        NEGLIGIBLE       +  .050        NEGLIGIBLE      NEGLIGIBLE
            -      51063.        NEGLIGIBLE       -  .050        NEGLIGIBLE      NEGLIGIBLE

401002010   +        438.        NEGLIGIBLE       +  .000        NEGLIGIBLE      NEGLIGIBLE
            -        438.        NEGLIGIBLE       -  .000        NEGLIGIBLE      NEGLIGIBLE
401002020   +        901.        NEGLIGIBLE       +  .001        NEGLIGIBLE      NEGLIGIBLE
            -        901.        NEGLIGIBLE       -  .001        NEGLIGIBLE      NEGLIGIBLE
401002030   +       2121.        NEGLIGIBLE       +  .002        NEGLIGIBLE      NEGLIGIBLE
            -       2121.        NEGLIGIBLE       -  .002        NEGLIGIBLE      NEGLIGIBLE
401002050   +       1389.        NEGLIGIBLE       +  .001        NEGLIGIBLE      NEGLIGIBLE
            -       1389.        NEGLIGIBLE       -  .001        NEGLIGIBLE      NEGLIGIBLE
401002990   +      50990.        NEGLIGIBLE       +  .050        NEGLIGIBLE      NEGLIGIBLE
            -      50990.        NEGLIGIBLE       -  .050        NEGLIGIBLE      NEGLIGIBLE

401999000   +      18320.        NEGLIGIBLE       +  .005        NEGLIGIBLE      NEGLIGIBLE
            -      18320.        NEGLIGIBLE       -  .005        NEGLIGIBLE      NEGLIGIBLE

401999990   +      18320.        NEGLIGIBLE       +  .005        NEGLIGIBLE      NEGLIGIBLE
            -      18320.        NEGLIGIBLE       -  .005        NEGLIGIBLE      NEGLIGIBLE

402001000   +      38745.        NEGLIGIBLE       +  .027        NEGLIGIBLE      NEGLIGIBLE
            -      38745.        NEGLIGIBLE       -  .027        NEGLIGIBLE      NEGLIGIBLE

402001010   +      38745.        NEGLIGIBLE       +  .027        NEGLIGIBLE      NEGLIGIBLE
            -      38745.        NEGLIGIBLE       -  .027        NEGLIGIBLE      NEGLIGIBLE

402001011   +      32202.        NEGLIGIBLE       +  .021        NEGLIGIBLE      NEGLIGIBLE
            -      32202.        NEGLIGIBLE       -  .021        NEGLIGIBLE      NEGLIGIBLE
402001012   +      21256.        NEGLIGIBLE       +  .017        NEGLIGIBLE      NEGLIGIBLE
            -      21256.        NEGLIGIBLE       -  .017        NEGLIGIBLE      NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

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                         HYDROCARBON EVAPORATION                                   PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976             RUN DATE= MAR 22,1977
 MODIFIED          TACRP          EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)          NOX                  HC          CO           PART
402001013  +        1690.      NEGLIGIBLE      +      .002     NEGLIGIBLE     NEGLIGIBLE
           -        1690.      NEGLIGIBLE      -      .002     NEGLIGIBLE     NEGLIGIBLE
402001014  +        1400.      NEGLIGIBLE      +      .001     NEGLIGIBLE     NEGLIGIBLE
           -        1390.      NEGLIGIBLE      -      .001     NEGLIGIBLE     NEGLIGIBLE
402001015  +        3370.      NEGLIGIBLE      +      .002     NEGLIGIBLE     NEGLIGIBLE
           -        3276.      NEGLIGIBLE      -      .002     NEGLIGIBLE     NEGLIGIBLE
402001016  +        1520.      NEGLIGIBLE      +      .002     NEGLIGIBLE     NEGLIGIBLE
           -        1420.      NEGLIGIBLE      -      .000     NEGLIGIBLE     NEGLIGIBLE
402001017  +         221.      NEGLIGIBLE      +      .000     NEGLIGIBLE     NEGLIGIBLE
           -         221.      NEGLIGIBLE      -      .000     NEGLIGIBLE     NEGLIGIBLE
402001018  +         316.      NEGLIGIBLE      +      .001     NEGLIGIBLE     NEGLIGIBLE
           -         316.      NEGLIGIBLE      -      .001     NEGLIGIBLE     NEGLIGIBLE
402001019  +         177.      NEGLIGIBLE      +      .000     NEGLIGIBLE     NEGLIGIBLE
           -         177.      NEGLIGIBLE      -      .000     NEGLIGIBLE     NEGLIGIBLE

402002000  +     3219300.      NEGLIGIBLE      +      .212     NEGLIGIBLE     NEGLIGIBLE
           -     3167600.      NEGLIGIBLE      -      .144     NEGLIGIBLE     NEGLIGIBLE

402002010  +     3219300.      NEGLIGIBLE      +      .212     NEGLIGIBLE     NEGLIGIBLE
           -     3167600.      NEGLIGIBLE      -      .144     NEGLIGIBLE     NEGLIGIBLE

402002011  +       44930.      NEGLIGIBLE      +      .022     NEGLIGIBLE     NEGLIGIBLE
           -       43930.      NEGLIGIBLE      -      .022     NEGLIGIBLE     NEGLIGIBLE
402002012  +        1200.      NEGLIGIBLE      +      .001     NEGLIGIBLE     NEGLIGIBLE
           -        1209.      NEGLIGIBLE      -      .001     NEGLIGIBLE     NEGLIGIBLE
402002013  +       43171.      NEGLIGIBLE      +      .028     NEGLIGIBLE     NEGLIGIBLE
           -       42171.      NEGLIGIBLE      -      .028     NEGLIGIBLE     NEGLIGIBLE
402002014  +  [illegible]      NEGLIGIBLE      +      .006     NEGLIGIBLE     NEGLIGIBLE
           -        9544.      NEGLIGIBLE      -      .009     NEGLIGIBLE     NEGLIGIBLE
402002015  +     3196000.      NEGLIGIBLE      +      .194     NEGLIGIBLE     NEGLIGIBLE
           -     3196000.      NEGLIGIBLE      -      .191     NEGLIGIBLE     NEGLIGIBLE
402002016  +       18130.      NEGLIGIBLE      +      .012     NEGLIGIBLE     NEGLIGIBLE
           -       18130.      NEGLIGIBLE      -      .012     NEGLIGIBLE     NEGLIGIBLE
402002017  +        2068.      NEGLIGIBLE      +      .001     NEGLIGIBLE     NEGLIGIBLE
           -        2068.      NEGLIGIBLE      -      .001     NEGLIGIBLE     NEGLIGIBLE
402002018  +       26446.      NEGLIGIBLE      +      .016     NEGLIGIBLE     NEGLIGIBLE
           -       26416.      NEGLIGIBLE      -      .016     NEGLIGIBLE     NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

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                              HYDROCARBON EVAPORATION                         PAGE  3
                                                                  RUN DATE= MAR 22,1977
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976
                                   EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED          TACRP                          HC             CO           PART
   SCC          (SCC UNITS)        NOX

402002019   +      111030.     NEGLIGIBLE    +   .012     NEGLIGIBLE    NEGLIGIBLE
            -      111030.     NEGLIGIBLE    -   .012     NEGLIGIBLE    NEGLIGIBLE

402003000   +       26012.     NEGLIGIBLE    +   .019     NEGLIGIBLE    NEGLIGIBLE
            -       26012.     NEGLIGIBLE    -   .019     NEGLIGIBLE    NEGLIGIBLE

402003010   +       26012.     NEGLIGIBLE    +   .015     NEGLIGIBLE    NEGLIGIBLE
            -       26012.     NEGLIGIBLE    -   .019     NEGLIGIBLE    NEGLIGIBLE

402003011   +       24880.     NEGLIGIBLE    +   .019     NEGLIGIBLE    NEGLIGIBLE
            -       24880.     NEGLIGIBLE    -   .018     NEGLIGIBLE    NEGLIGIBLE
402003013   +        1436.     NEGLIGIBLE    +   .001     NEGLIGIBLE    NEGLIGIBLE
            -        1436.     NEGLIGIBLE    -   .001     NEGLIGIBLE    NEGLIGIBLE
402003014   +          93.     NEGLIGIBLE    +   .000     NEGLIGIBLE    NEGLIGIBLE
            -          93.     NEGLIGIBLE    -   .000     NEGLIGIBLE    NEGLIGIBLE
402003017   +          31.     NEGLIGIBLE    +   .000     NEGLIGIBLE    NEGLIGIBLE
            -          31.     NEGLIGIBLE    -   .000     NEGLIGIBLE    NEGLIGIBLE
402003019   +          87.     NEGLIGIBLE    +   .000     NEGLIGIBLE    NEGLIGIBLE
            -          87.     NEGLIGIBLE    -   .000     NEGLIGIBLE    NEGLIGIBLE

402004000   +       11094.     NEGLIGIBLE    +   .010     NEGLIGIBLE    NEGLIGIBLE
            -       11094.     NEGLIGIBLE    -   .010     NEGLIGIBLE    NEGLIGIBLE

402004010   +       11094.     NEGLIGIBLE    +   .010     NEGLIGIBLE    NEGLIGIBLE
            -       11094.     NEGLIGIBLE    -   .010     NEGLIGIBLE    NEGLIGIBLE

402004011   +        3064.     NEGLIGIBLE    +   .004     NEGLIGIBLE    NEGLIGIBLE
            -        3064.     NEGLIGIBLE    -   .004     NEGLIGIBLE    NEGLIGIBLE
402004012   +       10631.     NEGLIGIBLE    +   .009     NEGLIGIBLE    NEGLIGIBLE
            -       10631.     NEGLIGIBLE    -   .009     NEGLIGIBLE    NEGLIGIBLE
402004015   +         851.     NEGLIGIBLE    +   .001     NEGLIGIBLE    NEGLIGIBLE
            -         851.     NEGLIGIBLE    -   .001     NEGLIGIBLE    NEGLIGIBLE
402004017   +           5.     NEGLIGIBLE    +   .000     NEGLIGIBLE    NEGLIGIBLE
            -           5.     NEGLIGIBLE    -   .000     NEGLIGIBLE    NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBON EVAPORATION PAGE 4

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE- MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
402005000	+	44162.	NEGLIGIBLE	+	.026	NEGLIGIBLE	NEGLIGIBLE
	-	44162.	NEGLIGIBLE	-	.026	NEGLIGIBLE	NEGLIGIBLE
402005010	+	44162.	NEGLIGIBLE	+	.026	NEGLIGIBLE	NEGLIGIBLE
	-	44162.	NEGLIGIBLE	-	.026	NEGLIGIBLE	NEGLIGIBLE
402005011	+	12284.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	12284.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402005012	+	42[illegible]79.	NEGLIGIBLE	+	.025	NEGLIGIBLE	NEGLIGIBLE
	-	42[illegible]79.	NEGLIGIBLE	-	.025	NEGLIGIBLE	NEGLIGIBLE
402005013	+	1843.	NEGLIGIBLE	+	.002	NEGLIGIBLE	NEGLIGIBLE
	-	1843.	NEGLIGIBLE	-	.002	NEGLIGIBLE	NEGLIGIBLE
402005016	+	41.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	41.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402005017	+	24.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	24.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006000	+	87689.	NEGLIGIBLE	+	.093	NEGLIGIBLE	NEGLIGIBLE
	-	87689.	NEGLIGIBLE	-	.093	NEGLIGIBLE	NEGLIGIBLE
402006010	+	87689.	NEGLIGIBLE	+	.093	NEGLIGIBLE	NEGLIGIBLE
	-	87689.	NEGLIGIBLE	-	.093	NEGLIGIBLE	NEGLIGIBLE
402006011	+	87522.	NEGLIGIBLE	+	.093	NEGLIGIBLE	NEGLIGIBLE
	-	87522.	NEGLIGIBLE	-	.093	NEGLIGIBLE	NEGLIGIBLE
402006012	+	5351.	NEGLIGIBLE	+	.003	NEGLIGIBLE	NEGLIGIBLE
	-	5351.	NEGLIGIBLE	-	.003	NEGLIGIBLE	NEGLIGIBLE
402006014	+	90.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	90.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006016	+	746.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	746.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402006017	+	33.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	33.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006019	+	11.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	11.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBON EVAPORATION PAGE 5

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	NOX	EMISSIONS (MILLIONS OF TONS / YEAR) HC		CO	PART
402007000	+	106620.	NEGLIGIBLE	+	.119	NEGLIGIBLE	NEGLIGIBLE
	-	106620.	NEGLIGIBLE	-	.119	NEGLIGIBLE	NEGLIGIBLE
402007010	+	106620.	NEGLIGIBLE	+	.119	NEGLIGIBLE	NEGLIGIBLE
	-	106620.	NEGLIGIBLE	-	.119	NEGLIGIBLE	NEGLIGIBLE
402007011	+	32025.	NEGLIGIBLE	+	.119	NEGLIGIBLE	NEGLIGIBLE
	-	32025.	NEGLIGIBLE	-	.119	NEGLIGIBLE	NEGLIGIBLE
402007012	+	26.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	26.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402007013	+	100080.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	100080.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402007014	+	1000.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	1000.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402007015	+	10013.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	10013.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402008000	+	27605.	NEGLIGIBLE	+	.018	NEGLIGIBLE	NEGLIGIBLE
	-	27605.	NEGLIGIBLE	-	.018	NEGLIGIBLE	NEGLIGIBLE
402008010	+	27605.	NEGLIGIBLE	+	.018	NEGLIGIBLE	NEGLIGIBLE
	-	27605.	NEGLIGIBLE	-	.018	NEGLIGIBLE	NEGLIGIBLE
402008011	+	6784.	NEGLIGIBLE	+	.006	NEGLIGIBLE	NEGLIGIBLE
	-	6784.	NEGLIGIBLE	-	.006	NEGLIGIBLE	NEGLIGIBLE
402008012	+	26758.	NEGLIGIBLE	+	.017	NEGLIGIBLE	NEGLIGIBLE
	-	26758.	NEGLIGIBLE	-	.017	NEGLIGIBLE	NEGLIGIBLE
402999000	+	253400.	NEGLIGIBLE	+	.040	NEGLIGIBLE	+ .002
	-	253400.	NEGLIGIBLE	-	.040	NEGLIGIBLE	- .002
402999990	+	253400.	NEGLIGIBLE	+	.040	NEGLIGIBLE	+ .002
	-	253400.	NEGLIGIBLE	-	.040	NEGLIGIBLE	- .002
403001000			NEGLIGIBLE	+	.332	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.331	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBON EVAPORATION PAGE 6

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
403001010	+	3280200.	NEGLIGIBLE	+	.267	NEGLIGIBLE	NEGLIGIBLE
	-	3280200.	NEGLIGIBLE	-	.267	NEGLIGIBLE	NEGLIGIBLE
403001011	+	3280200.	NEGLIGIBLE	+	.267	NEGLIGIBLE	NEGLIGIBLE
	-	3280200.	NEGLIGIBLE	-	.267	NEGLIGIBLE	NEGLIGIBLE
403001020	+	824620.	NEGLIGIBLE	+	.025	NEGLIGIBLE	NEGLIGIBLE
	-	824620.	NEGLIGIBLE	-	.025	NEGLIGIBLE	NEGLIGIBLE
403001021	+	824620.	NEGLIGIBLE	+	.025	NEGLIGIBLE	NEGLIGIBLE
	-	824620.	NEGLIGIBLE	-	.025	NEGLIGIBLE	NEGLIGIBLE
403001030	+	40447000.	NEGLIGIBLE	+	.212	NEGLIGIBLE	NEGLIGIBLE
	-	40447000.	NEGLIGIBLE	-	.212	NEGLIGIBLE	NEGLIGIBLE
403001031	+	40447000.	NEGLIGIBLE	+	.212	NEGLIGIBLE	NEGLIGIBLE
	-	40447000.	NEGLIGIBLE	-	.212	NEGLIGIBLE	NEGLIGIBLE
403001040	+	18216000.	NEGLIGIBLE	+	.083	NEGLIGIBLE	NEGLIGIBLE
	-	18216000.	NEGLIGIBLE	-	.082	NEGLIGIBLE	NEGLIGIBLE
403001041	+	18216000.	NEGLIGIBLE	+	.083	NEGLIGIBLE	NEGLIGIBLE
	-	18216000.	NEGLIGIBLE	-	.082	NEGLIGIBLE	NEGLIGIBLE
403001050	+	89442.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	89442.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
403001051	+	89442.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	89442.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
403001060	+	316230.	NEGLIGIBLE	+	.002	NEGLIGIBLE	NEGLIGIBLE
	-	316230.	NEGLIGIBLE	-	.002	NEGLIGIBLE	NEGLIGIBLE
403001061	+	316230.	NEGLIGIBLE	+	.002	NEGLIGIBLE	NEGLIGIBLE
	-	316230.	NEGLIGIBLE	-	.002	NEGLIGIBLE	NEGLIGIBLE
403001070	+	713860.	NEGLIGIBLE	+	.007	NEGLIGIBLE	NEGLIGIBLE
	-	713860.	NEGLIGIBLE	-	.007	NEGLIGIBLE	NEGLIGIBLE

Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

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                              HYDROCARBCN EVAPORATION                                   PAGE  7
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
  MODIFIED          TACRP                         EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC          (SCC UNITS)          NOX               HC            CO           PART
 403001071   +      713860.       NEGLIGIBLE     +   .007      NEGLIGIBLE    NEGLIGIBLE
             -      713860.       NEGLIGIBLE     -   .007      NEGLIGIBLE    NEGLIGIBLE

 403001500   +    11342000.       NEGLIGIBLE     +   .006      NEGLIGIBLE    NEGLIGIBLE
             -    11342000.       NEGLIGIBLE     -   .006      NEGLIGIBLE    NEGLIGIBLE

 403001501   +      800000.       NEGLIGIBLE     +   .001      NEGLIGIBLE    NEGLIGIBLE
             -      800000.       NEGLIGIBLE     -   .001      NEGLIGIBLE    NEGLIGIBLE

 403001510   +     8000000.       NEGLIGIBLE     +   .004      NEGLIGIBLE    NEGLIGIBLE
             -     8000000.       NEGLIGIBLE     -   .004      NEGLIGIBLE    NEGLIGIBLE

 403001511   +     8000000.       NEGLIGIBLE     +   .004      NEGLIGIBLE    NEGLIGIBLE
             -     8000000.       NEGLIGIBLE     -   .004      NEGLIGIBLE    NEGLIGIBLE

 403001520   +     8000000.       NEGLIGIBLE     +   .004      NEGLIGIBLE    NEGLIGIBLE
             -     8000000.       NEGLIGIBLE     -   .004      NEGLIGIBLE    NEGLIGIBLE

 403001521   +     8000000.       NEGLIGIBLE     +   .004      NEGLIGIBLE    NEGLIGIBLE
             -     8000000.       NEGLIGIBLE     -   .004      NEGLIGIBLE    NEGLIGIBLE

 403002000                        NEGLIGIBLE     +   .079      NEGLIGIBLE    NEGLIGIBLE
                                  NEGLIGIBLE     -   .075      NEGLIGIBLE    NEGLIGIBLE

 403002010   +     2218200.       NEGLIGIBLE     +   .016      NEGLIGIBLE    NEGLIGIBLE
             -     2218200.       NEGLIGIBLE     -   .016      NEGLIGIBLE    NEGLIGIBLE

 403002011   +     2218200.       NEGLIGIBLE     +   .016      NEGLIGIBLE    NEGLIGIBLE
             -     2218200.       NEGLIGIBLE     -   .016      NEGLIGIBLE    NEGLIGIBLE

 403002020   +     5590200.       NEGLIGIBLE     +   .016      NEGLIGIBLE    NEGLIGIBLE
             -     5590200.       NEGLIGIBLE     -   .013      NEGLIGIBLE    NEGLIGIBLE

 403002021   +     5590200.       NEGLIGIBLE     +   .016      NEGLIGIBLE    NEGLIGIBLE
             -     5590200.       NEGLIGIBLE     -   .013      NEGLIGIBLE    NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

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                                                                                PAGE  8
                          HYDROCARBON EVAPORATION
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976            RUN DATE= MAR 22,1977
                                     EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED          TACRP                                                        PART
  SCC          (SCC UNITS)         NOX            HC           CO
403002030   +   2236100.       NEGLIGIBLE    +   .013     NEGLIGIBLE     NEGLIGIBLE
            -   2236100.       NEGLIGIBLE    -   .013     NEGLIGIBLE     NEGLIGIBLE

403002031   +   2236100.       NEGLIGIBLE    +   .013     NEGLIGIBLE     NEGLIGIBLE
            -   2236100.       NEGLIGIBLE    -   .013     NEGLIGIBLE     NEGLIGIBLE

403002040   +   8246200.       NEGLIGIBLE    +   .074     NEGLIGIBLE     NEGLIGIBLE
            -   8246200.       NEGLIGIBLE    -   .070     NEGLIGIBLE     NEGLIGIBLE

403002041   +   8246200.       NEGLIGIBLE    +   .074     NEGLIGIBLE     NEGLIGIBLE
            -   8246200.       NEGLIGIBLE    -   .070     NEGLIGIBLE     NEGLIGIBLE

403002050   +     45891.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     45891.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403002051   +     45891.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     45891.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403002060   +     15811.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     15811.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403002061   +     15811.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     15811.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403002070   +     47434.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     47434.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403002071   +     47434.       NEGLIGIBLE    +   .000     NEGLIGIBLE     NEGLIGIBLE
            -     47434.       NEGLIGIBLE    -   .000     NEGLIGIBLE     NEGLIGIBLE

403003000   +    371080.       NEGLIGIBLE    +   .011     NEGLIGIBLE     NEGLIGIBLE
            -    371080.       NEGLIGIBLE    -   .011     NEGLIGIBLE     NEGLIGIBLE

403003020   +    371080.       NEGLIGIBLE    +   .011     NEGLIGIBLE     NEGLIGIBLE
            -    371080.       NEGLIGIBLE    -   .011     NEGLIGIBLE     NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

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                              HYDROCARBON EVAPORATION                          PAGE  9
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976          RUN DATE= MAR 22,1977
 MODIFIED          TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX            HC            CO           PART

403999000    +    8246200.      NEGLIGIBLE    +  .039      NEGLIGIBLE    NEGLIGIBLE
             -    8246200.      NEGLIGIBLE    -  .047      NEGLIGIBLE    NEGLIGIBLE

403999990    +    8246200.      NEGLIGIBLE    +  .039      NEGLIGIBLE    NEGLIGIBLE
             -    8246200.      NEGLIGIBLE    -  .047      NEGLIGIBLE    NEGLIGIBLE

406001000    +    7161400.      NEGLIGIBLE    +  .082      NEGLIGIBLE    NEGLIGIBLE
             -    7161400.      NEGLIGIBLE    -  .082      NEGLIGIBLE    NEGLIGIBLE

406001010    +    4921200.      NEGLIGIBLE    +  .032      NEGLIGIBLE    NEGLIGIBLE
             -    4921200.      NEGLIGIBLE    -  .052      NEGLIGIBLE    NEGLIGIBLE

406001011    +      89442.      NEGLIGIBLE    +  .001      NEGLIGIBLE    NEGLIGIBLE
             -      89442.      NEGLIGIBLE    -  .001      NEGLIGIBLE    NEGLIGIBLE
406001012    +    4920400.      NEGLIGIBLE    +  .032      NEGLIGIBLE    NEGLIGIBLE
             -    4920400.      NEGLIGIBLE    -  .052      NEGLIGIBLE    NEGLIGIBLE

406001020    +     456520.      NEGLIGIBLE    +  .003      NEGLIGIBLE    NEGLIGIBLE
             -     456520.      NEGLIGIBLE    -  .005      NEGLIGIBLE    NEGLIGIBLE

406001021    +       8854.      NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -       8854.      NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE
406001022    +     456440.      NEGLIGIBLE    +  .003      NEGLIGIBLE    NEGLIGIBLE
             -     456440.      NEGLIGIBLE    -  .005      NEGLIGIBLE    NEGLIGIBLE

406001260    +    5162200.      NEGLIGIBLE    +  .075      NEGLIGIBLE    NEGLIGIBLE
             -    5162200.      NEGLIGIBLE    -  .062      NEGLIGIBLE    NEGLIGIBLE

406001261    +      89442.      NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -      89442.      NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE
406001262    +    5161400.      NEGLIGIBLE    +  .075      NEGLIGIBLE    NEGLIGIBLE
             -    5161400.      NEGLIGIBLE    -  .062      NEGLIGIBLE    NEGLIGIBLE

406001270    +     459870.      NEGLIGIBLE    +  .010      NEGLIGIBLE    NEGLIGIBLE
             -     459870.      NEGLIGIBLE    -  .010      NEGLIGIBLE    NEGLIGIBLE

406001271    +      56080.      NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -      56080.      NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE
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Table 6-2-b. 1976 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBON EVAPORATION PAGE 10

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
406001272	+	456440.	NEGLIGIBLE	+	.010	NEGLIGIBLE	NEGLIGIBLE
	-	456440.	NEGLIGIBLE	-	.010	NEGLIGIBLE	NEGLIGIBLE
406002000	+	15430000.	NEGLIGIBLE	+	.028	NEGLIGIBLE	NEGLIGIBLE
	-	15430000.	NEGLIGIBLE	-	.031	NEGLIGIBLE	NEGLIGIBLE
406002010	+	9042900.	NEGLIGIBLE	+	.018	NEGLIGIBLE	NEGLIGIBLE
	-	9042900.	NEGLIGIBLE	-	.018	NEGLIGIBLE	NEGLIGIBLE
406002020	+	4640000.	NEGLIGIBLE	+	.007	NEGLIGIBLE	NEGLIGIBLE
	-	4640000.	NEGLIGIBLE	-	.007	NEGLIGIBLE	NEGLIGIBLE
406002260	+	9042900.	NEGLIGIBLE	+	.012	NEGLIGIBLE	NEGLIGIBLE
	-	9042900.	NEGLIGIBLE	-	.012	NEGLIGIBLE	NEGLIGIBLE
406002270	+	7280100.	NEGLIGIBLE	+	.017	NEGLIGIBLE	NEGLIGIBLE
	-	7280100.	NEGLIGIBLE	-	.023	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES

HYDROCARBON EVAPORATION PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
401001000	43000.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
401001010	40570.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
401001020	2430.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
401002000	114560.	NEGLIGIBLE	.096	NEGLIGIBLE	NEGLIGIBLE
401002010	160.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
401002020	1070.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
401002030	14213.	NEGLIGIBLE	.006	NEGLIGIBLE	NEGLIGIBLE
401002050	1670.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
401002990	97450.	NEGLIGIBLE	.088	NEGLIGIBLE	NEGLIGIBLE
401999000	130690.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
401999990	130690.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
402001000	601620.	NEGLIGIBLE	.145	NEGLIGIBLE	NEGLIGIBLE
402001010	601620.	NEGLIGIBLE	.145	NEGLIGIBLE	NEGLIGIBLE
402001011	460000.	NEGLIGIBLE	.129	NEGLIGIBLE	NEGLIGIBLE
402001012	99000.	NEGLIGIBLE	.011	NEGLIGIBLE	NEGLIGIBLE
402001013	8192.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001014	6184.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001015	12134.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001016	8003.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402001017	2753.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402001018	3762.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402001019	1592.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402002000	6642900.	NEGLIGIBLE	.289	NEGLIGIBLE	NEGLIGIBLE
402002010	6642900.	NEGLIGIBLE	.289	NEGLIGIBLE	NEGLIGIBLE
402002011	86370.	NEGLIGIBLE	.040	NEGLIGIBLE	NEGLIGIBLE
402002012	13850.	NEGLIGIBLE	.003	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

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                             HYDROCARBON EVAPORATION                                 PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)         NOX             HC             CO           PART

402002013          94540.      NEGLIGIBLE        .041        NEGLIGIBLE    NEGLIGIBLE
402002014          18330.      NEGLIGIBLE        .016        NEGLIGIBLE    NEGLIGIBLE
402002015        6113000.      NEGLIGIBLE        .128        NEGLIGIBLE    NEGLIGIBLE
402002016          48830.      NEGLIGIBLE        .009        NEGLIGIBLE    NEGLIGIBLE
402002017           3956.      NEGLIGIBLE        .001        NEGLIGIBLE    NEGLIGIBLE
402002018          50620.      NEGLIGIBLE        .029        NEGLIGIBLE    NEGLIGIBLE
402002019         213400.      NEGLIGIBLE        .021        NEGLIGIBLE    NEGLIGIBLE

402003000         401970.      NEGLIGIBLE        .133        NEGLIGIBLE    NEGLIGIBLE

402003010         401970.      NEGLIGIBLE        .133        NEGLIGIBLE    NEGLIGIBLE

402003011         394000.      NEGLIGIBLE        .130        NEGLIGIBLE    NEGLIGIBLE
402003013           7040.      NEGLIGIBLE        .002        NEGLIGIBLE    NEGLIGIBLE
402003014            413.      NEGLIGIBLE        .000        NEGLIGIBLE    NEGLIGIBLE
402003017            412.      NEGLIGIBLE        .000        NEGLIGIBLE    NEGLIGIBLE
402003019            106.      NEGLIGIBLE        .000        NEGLIGIBLE    NEGLIGIBLE

402004000          97988.      NEGLIGIBLE        .036        NEGLIGIBLE    NEGLIGIBLE

402004010          97988.      NEGLIGIBLE        .036        NEGLIGIBLE    NEGLIGIBLE

402004011          44400.      NEGLIGIBLE        .016        NEGLIGIBLE    NEGLIGIBLE
402004012          48960.      NEGLIGIBLE        .018        NEGLIGIBLE    NEGLIGIBLE
402004015           4562.      NEGLIGIBLE        .002        NEGLIGIBLE    NEGLIGIBLE
402004017             66.      NEGLIGIBLE        .000        NEGLIGIBLE    NEGLIGIBLE

402005000         382350.      NEGLIGIBLE        .110        NEGLIGIBLE    NEGLIGIBLE

402005010         382350.      NEGLIGIBLE        .110        NEGLIGIBLE    NEGLIGIBLE

402005011         176900.      NEGLIGIBLE        .050        NEGLIGIBLE    NEGLIGIBLE
402005012         195840.      NEGLIGIBLE        .056        NEGLIGIBLE    NEGLIGIBLE
402005013           9070.      NEGLIGIBLE        .003        NEGLIGIBLE    NEGLIGIBLE
402005016            235.      NEGLIGIBLE        .000        NEGLIGIBLE    NEGLIGIBLE
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Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 3

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
402005017	303.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006000	1294500.	NEGLIGIBLE	.344	NEGLIGIBLE	NEGLIGIBLE
402006010	1294500.	NEGLIGIBLE	.344	NEGLIGIBLE	NEGLIGIBLE
402006011	1265000.	NEGLIGIBLE	.336	NEGLIGIBLE	NEGLIGIBLE
402006012	24480.	NEGLIGIBLE	.007	NEGLIGIBLE	NEGLIGIBLE
402006014	395.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006016	4174.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402006017	385.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402006019	102.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007000	1652700.	NEGLIGIBLE	.239	NEGLIGIBLE	NEGLIGIBLE
402007010	1652700.	NEGLIGIBLE	.239	NEGLIGIBLE	NEGLIGIBLE
402007011	349100.	NEGLIGIBLE	.227	NEGLIGIBLE	NEGLIGIBLE
402007012	282.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007013	1102800.	NEGLIGIBLE	.011	NEGLIGIBLE	NEGLIGIBLE
402007014	11137.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
402007015	189400.	NEGLIGIBLE	.001	NEGLIGIBLE	NEGLIGIBLE
402008000	220940.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
402008010	220940.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
402008011	98540.	NEGLIGIBLE	.030	NEGLIGIBLE	NEGLIGIBLE
402008012	122400.	NEGLIGIBLE	.037	NEGLIGIBLE	NEGLIGIBLE
402999000	1693600.	NEGLIGIBLE	.143	NEGLIGIBLE	.012
402999990	1693600.	NEGLIGIBLE	.143	NEGLIGIBLE	.012

Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 4

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
403001000		NEGLIGIBLE	.082	NEGLIGIBLE	NEGLIGIBLE
403001010	0.	0.000	0.000	0.000	0.000
403001011	0.	0.000	0.000	0.000	0.000
403001020	0.	0.000	0.000	0.000	0.000
403001021	0.	0.000	0.000	0.000	0.000
403001030	0.	0.000	0.000	0.000	0.000
403001031	0.	0.000	0.000	0.000	0.000
403001040	0.	0.000	0.000	0.000	0.000
403001041	0.	0.000	0.000	0.000	0.000
403001050	124000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001051	124000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001060	500000.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
403001061	500000.	NEGLIGIBLE	.004	NEGLIGIBLE	NEGLIGIBLE
403001070	6932900.	NEGLIGIBLE	.050	NEGLIGIBLE	NEGLIGIBLE
403001071	6932900.	NEGLIGIBLE	.050	NEGLIGIBLE	NEGLIGIBLE
403001500	52050000.	NEGLIGIBLE	.026	NEGLIGIBLE	NEGLIGIBLE
403001501	1570000.	NEGLIGIBLE	.002	NEGLIGIBLE	NEGLIGIBLE
403001510	20800000.	NEGLIGIBLE	.010	NEGLIGIBLE	NEGLIGIBLE
403001511	20800000.	NEGLIGIBLE	.010	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 5

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
403001520	29680000.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
403001521	29680000.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
403002000		NEGLIGIBLE	.212	NEGLIGIBLE	NEGLIGIBLE
403002010	2920000.	NEGLIGIBLE	.019	NEGLIGIBLE	NEGLIGIBLE
403002011	2920000.	NEGLIGIBLE	.019	NEGLIGIBLE	NEGLIGIBLE
403002020	0.	0.000	0.000	0.000	0.000
403002021	0.	0.000	0.000	0.000	0.000
403002030	12660000.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
403002031	12660000.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
403002040	79800000.	NEGLIGIBLE	.125	NEGLIGIBLE	NEGLIGIBLE
403002041	79800000.	NEGLIGIBLE	.125	NEGLIGIBLE	NEGLIGIBLE
403002050	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002051	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002060	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002061	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002070	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002071	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403003000	32360000.	NEGLIGIBLE	.142	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

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                                HYDROCARBON EVAPORATION                              PAGE  6
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX              HC            CO           PART
403003020        32360000.       NEGLIGIBLE          .142       NEGLIGIBLE    NEGLIGIBLE

403999000        15000000.       NEGLIGIBLE          .069       NEGLIGIBLE    NEGLIGIBLE

403999990        15000000.       NEGLIGIBLE          .069       NEGLIGIBLE    NEGLIGIBLE

406001000        83302000.       NEGLIGIBLE          .090       NEGLIGIBLE    NEGLIGIBLE

406001010         7900000.       NEGLIGIBLE          .049       NEGLIGIBLE    NEGLIGIBLE

406001011               0.          0.000           0.000          0.000         0.000
406001012         7900000.       NEGLIGIBLE          .049       NEGLIGIBLE    NEGLIGIBLE

406001020         2106000.       NEGLIGIBLE          .011       NEGLIGIBLE    NEGLIGIBLE

406001021           20000.       NEGLIGIBLE          .000       NEGLIGIBLE    NEGLIGIBLE
406001022         2086000.       NEGLIGIBLE          .011       NEGLIGIBLE    NEGLIGIBLE

406001260        58500000.       NEGLIGIBLE          .024       NEGLIGIBLE    NEGLIGIBLE

406001261               0.          0.000           0.000          0.000         0.000
406001262        58500000.       NEGLIGIBLE          .024       NEGLIGIBLE    NEGLIGIBLE

406001270        14796000.       NEGLIGIBLE          .006       NEGLIGIBLE    NEGLIGIBLE

406001271          396000.       NEGLIGIBLE          .000       NEGLIGIBLE    NEGLIGIBLE
406001272        14400000.       NEGLIGIBLE          .006       NEGLIGIBLE    NEGLIGIBLE

406002000       113600000.       NEGLIGIBLE          .213       NEGLIGIBLE    NEGLIGIBLE

406002010         6300000.       NEGLIGIBLE          .003       NEGLIGIBLE    NEGLIGIBLE
406002020         7000000.       NEGLIGIBLE          .003       NEGLIGIBLE    NEGLIGIBLE
406002260         6300000.       NEGLIGIBLE          .001       NEGLIGIBLE    NEGLIGIBLE
406002270        94000000.       NEGLIGIBLE          .207       NEGLIGIBLE    NEGLIGIBLE
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Table 6-3-a. 1981 HC EVAPORATION EMISSIONS AND CHARGE RATES (Continued)

HYDROCARBON EVAPORATION PAGE 5

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
403001520	29680000.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
403001521	29680000.	NEGLIGIBLE	.014	NEGLIGIBLE	NEGLIGIBLE
403002000		NEGLIGIBLE	.212	NEGLIGIBLE	NEGLIGIBLE
403002010	2920000.	NEGLIGIBLE	.019	NEGLIGIBLE	NEGLIGIBLE
403002011	2920000.	NEGLIGIBLE	.019	NEGLIGIBLE	NEGLIGIBLE
403002020	0.	0.000	0.000	0.000	0.000
403002021	0.	0.000	0.000	0.000	0.000
403002030	12660000.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
403002031	12660000.	NEGLIGIBLE	.067	NEGLIGIBLE	NEGLIGIBLE
403002040	79800000.	NEGLIGIBLE	.125	NEGLIGIBLE	NEGLIGIBLE
403002041	79800000.	NEGLIGIBLE	.125	NEGLIGIBLE	NEGLIGIBLE
403002050	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002051	89700.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002060	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002061	52000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002070	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403002071	154000.	NEGLIGIBLE	.000	NEGLIGIBLE	NEGLIGIBLE
403003000	32360000.	NEGLIGIBLE	.142	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES

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                         HYDROCARBON EVAPORATION                        PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)       NOX              HC            CO          PART
401001000    +      33470.    NEGLIGIBLE    +  .006    NEGLIGIBLE   NEGLIGIBLE
             -      20053.    NEGLIGIBLE    -  .001    NEGLIGIBLE   NEGLIGIBLE

401001010    +      19905.    NEGLIGIBLE    +  .004    NEGLIGIBLE   NEGLIGIBLE
             -      19905.    NEGLIGIBLE    -  .000    NEGLIGIBLE   NEGLIGIBLE
401001020    +      26907.    NEGLIGIBLE    +  .004    NEGLIGIBLE   NEGLIGIBLE
             -       2430.    NEGLIGIBLE    -  .000    NEGLIGIBLE   NEGLIGIBLE

401002000    +     100730.    NEGLIGIBLE    +  .093    NEGLIGIBLE   NEGLIGIBLE
             -      97631.    NEGLIGIBLE    -  .088    NEGLIGIBLE   NEGLIGIBLE

401002010    +        917.    NEGLIGIBLE    +  .001    NEGLIGIBLE   NEGLIGIBLE
             -        159.    NEGLIGIBLE    -  .000    NEGLIGIBLE   NEGLIGIBLE
401002020    +       2061.    NEGLIGIBLE    +  .002    NEGLIGIBLE   NEGLIGIBLE
             -       1069.    NEGLIGIBLE    -  .001    NEGLIGIBLE   NEGLIGIBLE
401002030    +       5608.    NEGLIGIBLE    +  .008    NEGLIGIBLE   NEGLIGIBLE
             -       5608.    NEGLIGIBLE    -  .004    NEGLIGIBLE   NEGLIGIBLE
401002050    +       3275.    NEGLIGIBLE    +  .003    NEGLIGIBLE   NEGLIGIBLE
             -       1670.    NEGLIGIBLE    -  .002    NEGLIGIBLE   NEGLIGIBLE
401002990    +     100500.    NEGLIGIBLE    +  .093    NEGLIGIBLE   NEGLIGIBLE
             -      97450.    NEGLIGIBLE    -  .088    NEGLIGIBLE   NEGLIGIBLE

401999000    +      32003.    NEGLIGIBLE    +  .015    NEGLIGIBLE   NEGLIGIBLE
             -      32003.    NEGLIGIBLE    -  .014    NEGLIGIBLE   NEGLIGIBLE

401999990    +      32003.    NEGLIGIBLE    +  .015    NEGLIGIBLE   NEGLIGIBLE
             -      32003.    NEGLIGIBLE    -  .014    NEGLIGIBLE   NEGLIGIBLE

402001000    +      76850.    NEGLIGIBLE    +  .138    NEGLIGIBLE   NEGLIGIBLE
             -      76850.    NEGLIGIBLE    -  .105    NEGLIGIBLE   NEGLIGIBLE

402001010    +      76850.    NEGLIGIBLE    +  .138    NEGLIGIBLE   NEGLIGIBLE
             -      76850.    NEGLIGIBLE    -  .105    NEGLIGIBLE   NEGLIGIBLE

402001011    +      61508.    NEGLIGIBLE    +  .131    NEGLIGIBLE   NEGLIGIBLE
             -      61508.    NEGLIGIBLE    -  .104    NEGLIGIBLE   NEGLIGIBLE
402001012    +      45572.    NEGLIGIBLE    +  .045    NEGLIGIBLE   NEGLIGIBLE
             -      45572.    NEGLIGIBLE    -  .008    NEGLIGIBLE   NEGLIGIBLE
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Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBCN EVAPORATION PAGE 2

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
402001013	+	2755.	NEGLIGIBLE	+	.004	NEGLIGIBLE	NEGLIGIBLE
	-	2755.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402001014	+	2659.	NEGLIGIBLE	+	.003	NEGLIGIBLE	NEGLIGIBLE
	-	2659.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402001015	+	4742.	NEGLIGIBLE	+	.005	NEGLIGIBLE	NEGLIGIBLE
	-	4742.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402001016	+	2738.	NEGLIGIBLE	+	.004	NEGLIGIBLE	NEGLIGIBLE
	-	2738.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402001017	+	34[illegible].	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	34[illegible].	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402001018	+	1005.	NEGLIGIBLE	+	.002	NEGLIGIBLE	NEGLIGIBLE
	-	1005.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402001019	+	300.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	300.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402002000	+	6826800.	NEGLIGIBLE	+	.260	NEGLIGIBLE	NEGLIGIBLE
	-	6118500.	NEGLIGIBLE	-	.146	NEGLIGIBLE	NEGLIGIBLE
402002010	+	6826800.	NEGLIGIBLE	+	.260	NEGLIGIBLE	NEGLIGIBLE
	-	6118500.	NEGLIGIBLE	-	.146	NEGLIGIBLE	NEGLIGIBLE
402002011	+	95131.	NEGLIGIBLE	+	.044	NEGLIGIBLE	NEGLIGIBLE
	-	86370.	NEGLIGIBLE	-	.040	NEGLIGIBLE	NEGLIGIBLE
402002012	+	15270.	NEGLIGIBLE	+	.003	NEGLIGIBLE	NEGLIGIBLE
	-	13850.	NEGLIGIBLE	-	.003	NEGLIGIBLE	NEGLIGIBLE
402002013	+	104240.	NEGLIGIBLE	+	.046	NEGLIGIBLE	NEGLIGIBLE
	-	94540.	NEGLIGIBLE	-	.041	NEGLIGIBLE	NEGLIGIBLE
402002014	+	20213.	NEGLIGIBLE	+	.018	NEGLIGIBLE	NEGLIGIBLE
	-	18329.	NEGLIGIBLE	-	.016	NEGLIGIBLE	NEGLIGIBLE
402002015	+	6767200.	NEGLIGIBLE	+	.187	NEGLIGIBLE	NEGLIGIBLE
	-	6113000.	NEGLIGIBLE	-	.128	NEGLIGIBLE	NEGLIGIBLE
402002016	+	855060.	NEGLIGIBLE	+	.162	NEGLIGIBLE	NEGLIGIBLE
	-	48830.	NEGLIGIBLE	-	.009	NEGLIGIBLE	NEGLIGIBLE
402002017	+	4366.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	3956.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402002018	+	55891.	NEGLIGIBLE	+	.032	NEGLIGIBLE	NEGLIGIBLE
	-	50620.	NEGLIGIBLE	-	.029	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

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                               HYDROCARBON EVAPORATION                              PAGE  3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981           RUN DATE= MAR 22,1977
 MODIFIED          TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)         NOX             HC             CO              PART
402002019    +     235080.     NEGLIGIBLE     +  .024     NEGLIGIBLE     NEGLIGIBLE
             -     213400.     NEGLIGIBLE     -  .021     NEGLIGIBLE     NEGLIGIBLE

402003000    +      51220.     NEGLIGIBLE     +  .129     NEGLIGIBLE     NEGLIGIBLE
             -      51220.     NEGLIGIBLE     -  .106     NEGLIGIBLE     NEGLIGIBLE

402003010    +      51220.     NEGLIGIBLE     +  .129     NEGLIGIBLE     NEGLIGIBLE
             -      51220.     NEGLIGIBLE     -  .106     NEGLIGIBLE     NEGLIGIBLE

402003011    +      51166.     NEGLIGIBLE     +  .129     NEGLIGIBLE     NEGLIGIBLE
             -      51166.     NEGLIGIBLE     -  .106     NEGLIGIBLE     NEGLIGIBLE
402003013    +       2344.     NEGLIGIBLE     +  .002     NEGLIGIBLE     NEGLIGIBLE
             -       2344.     NEGLIGIBLE     -  .002     NEGLIGIBLE     NEGLIGIBLE
402003014    +        177.     NEGLIGIBLE     +  .000     NEGLIGIBLE     NEGLIGIBLE
             -        177.     NEGLIGIBLE     -  .000     NEGLIGIBLE     NEGLIGIBLE
402003017    +         51.     NEGLIGIBLE     +  .000     NEGLIGIBLE     NEGLIGIBLE
             -         51.     NEGLIGIBLE     -  .000     NEGLIGIBLE     NEGLIGIBLE
402003019    +         89.     NEGLIGIBLE     +  .000     NEGLIGIBLE     NEGLIGIBLE
             -         89.     NEGLIGIBLE     -  .000     NEGLIGIBLE     NEGLIGIBLE

402004000    +      23595.     NEGLIGIBLE     +  .027     NEGLIGIBLE     NEGLIGIBLE
             -      23595.     NEGLIGIBLE     -  .021     NEGLIGIBLE     NEGLIGIBLE

402004010    +      23595.     NEGLIGIBLE     +  .027     NEGLIGIBLE     NEGLIGIBLE
             -      23595.     NEGLIGIBLE     -  .021     NEGLIGIBLE     NEGLIGIBLE

402004011    +       5863.     NEGLIGIBLE     +  .017     NEGLIGIBLE     NEGLIGIBLE
             -       5863.     NEGLIGIBLE     -  .013     NEGLIGIBLE     NEGLIGIBLE
402004012    +      22786.     NEGLIGIBLE     +  .021     NEGLIGIBLE     NEGLIGIBLE
             -      22786.     NEGLIGIBLE     -  .017     NEGLIGIBLE     NEGLIGIBLE
402004015    +       1782.     NEGLIGIBLE     +  .002     NEGLIGIBLE     NEGLIGIBLE
             -       1782.     NEGLIGIBLE     -  .001     NEGLIGIBLE     NEGLIGIBLE
402004017    +          8.     NEGLIGIBLE     +  .003     NEGLIGIBLE     NEGLIGIBLE
             -          8.     NEGLIGIBLE     -  .000     NEGLIGIBLE     NEGLIGIBLE
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Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBCN EVAPORATION PAGE 4

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR)				
			NOX		HC	CO	PART
402005000	+	94088.	NEGLIGIBLE	+	.080	NEGLIGIBLE	NEGLIGIBLE
	-	94088.	NEGLIGIBLE	-	.066	NEGLIGIBLE	NEGLIGIBLE
402005010	+	94088.	NEGLIGIBLE	+	.080	NEGLIGIBLE	NEGLIGIBLE
	-	94088.	NEGLIGIBLE	-	.066	NEGLIGIBLE	NEGLIGIBLE
402005011	+	23397.	NEGLIGIBLE	+	.051	NEGLIGIBLE	NEGLIGIBLE
	-	23397.	NEGLIGIBLE	-	.041	NEGLIGIBLE	NEGLIGIBLE
402005012	+	[illegible]	NEGLIGIBLE	+	.062	NEGLIGIBLE	NEGLIGIBLE
	-	[illegible]	NEGLIGIBLE	-	.052	NEGLIGIBLE	NEGLIGIBLE
402005013	+	3041.	NEGLIGIBLE	+	.004	NEGLIGIBLE	NEGLIGIBLE
	-	3041.	NEGLIGIBLE	-	.003	NEGLIGIBLE	NEGLIGIBLE
402005016	+	80.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	80.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402005017	+	37.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	37.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006000	+	167120.	NEGLIGIBLE	+	.362	NEGLIGIBLE	NEGLIGIBLE
	-	167120.	NEGLIGIBLE	-	.273	NEGLIGIBLE	NEGLIGIBLE
402006010	+	167120.	NEGLIGIBLE	+	.362	NEGLIGIBLE	NEGLIGIBLE
	-	167120.	NEGLIGIBLE	-	.273	NEGLIGIBLE	NEGLIGIBLE
402006011	+	166720.	NEGLIGIBLE	+	.362	NEGLIGIBLE	NEGLIGIBLE
	-	166720.	NEGLIGIBLE	-	.272	NEGLIGIBLE	NEGLIGIBLE
402006012	+	11481.	NEGLIGIBLE	+	.008	NEGLIGIBLE	NEGLIGIBLE
	-	11481.	NEGLIGIBLE	-	.006	NEGLIGIBLE	NEGLIGIBLE
402006014	+	170.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	170.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006016	+	1434.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	1434.	NEGLIGIBLE	-	.001	NEGLIGIBLE	NEGLIGIBLE
402006017	+	50.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	50.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402006019	+	19.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	19.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBCN EVAPORATION PAGE 5

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
402007000	+	106980.	NEGLIGIBLE	+	.124	NEGLIGIBLE	NEGLIGIBLE
	-	106980.	NEGLIGIBLE	-	.168	NEGLIGIBLE	NEGLIGIBLE
402007010	+	106980.	NEGLIGIBLE	+	.124	NEGLIGIBLE	NEGLIGIBLE
	-	106980.	NEGLIGIBLE	-	.168	NEGLIGIBLE	NEGLIGIBLE
402007011	+	32129.	NEGLIGIBLE	+	.124	NEGLIGIBLE	NEGLIGIBLE
	-	32129.	NEGLIGIBLE	-	.168	NEGLIGIBLE	NEGLIGIBLE
402007012	+	26.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	26.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402007013	+	100420.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	100420.	NEGLIGIBLE	-	.006	NEGLIGIBLE	NEGLIGIBLE
402007014	+	1004.	NEGLIGIBLE	+	.001	NEGLIGIBLE	NEGLIGIBLE
	-	1004.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402007015	+	18068.	NEGLIGIBLE	+	.000	NEGLIGIBLE	NEGLIGIBLE
	-	18068.	NEGLIGIBLE	-	.000	NEGLIGIBLE	NEGLIGIBLE
402008000	+	58855.	NEGLIGIBLE	+	.052	NEGLIGIBLE	NEGLIGIBLE
	-	58855.	NEGLIGIBLE	-	.042	NEGLIGIBLE	NEGLIGIBLE
402008010	+	58855.	NEGLIGIBLE	+	.052	NEGLIGIBLE	NEGLIGIBLE
	-	58855.	NEGLIGIBLE	-	.042	NEGLIGIBLE	NEGLIGIBLE
402008011	+	12962.	NEGLIGIBLE	+	.030	NEGLIGIBLE	NEGLIGIBLE
	-	12962.	NEGLIGIBLE	-	.024	NEGLIGIBLE	NEGLIGIBLE
402008012	+	57409.	NEGLIGIBLE	+	.042	NEGLIGIBLE	NEGLIGIBLE
	-	57409.	NEGLIGIBLE	-	.035	NEGLIGIBLE	NEGLIGIBLE
402999000	+	432910.	NEGLIGIBLE	+	.095	NEGLIGIBLE	+ .003
	-	432910.	NEGLIGIBLE	-	.095	NEGLIGIBLE	- .003
402999990	+	432910.	NEGLIGIBLE	+	.095	NEGLIGIBLE	+ .003
	-	432910.	NEGLIGIBLE	-	.095	NEGLIGIBLE	- .003
403001000			NEGLIGIBLE	+	.015	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.035	NEGLIGIBLE	NEGLIGIBLE

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

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                                     HYDROCARBON EVAPORATION                                   PAGE  6
             TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981       RUN DATE= MAR 22,1977
  MODIFIED         TACRP                    EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC         (SCC UNITS)          NOX               HC                CO               PART
 403001010    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001011    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001020    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001021    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001030    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001031    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001040    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001041    +             0.     + 0.000         + 0.000         + 0.000         + 0.000
              -             0.     - 0.000         - 0.000         - 0.000         - 0.000
 403001050    +        120420.     NEGLIGIBLE      +   .002        NEGLIGIBLE      NEGLIGIBLE
              -        120420.     NEGLIGIBLE      -   .002        NEGLIGIBLE      NEGLIGIBLE
 403001051    +        120420.     NEGLIGIBLE      +   .002        NEGLIGIBLE      NEGLIGIBLE
              -        120420.     NEGLIGIBLE      -   .002        NEGLIGIBLE      NEGLIGIBLE
 403001060    +        460980.     NEGLIGIBLE      +   .003        NEGLIGIBLE      NEGLIGIBLE
              -        460980.     NEGLIGIBLE      -   .004        NEGLIGIBLE      NEGLIGIBLE
 403001061    +        460980.     NEGLIGIBLE      +   .003        NEGLIGIBLE      NEGLIGIBLE
              -        460980.     NEGLIGIBLE      -   .004        NEGLIGIBLE      NEGLIGIBLE
 403001070    +        854460.     NEGLIGIBLE      +   .008        NEGLIGIBLE      NEGLIGIBLE
              -        854460.     NEGLIGIBLE      -   .027        NEGLIGIBLE      NEGLIGIBLE
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Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

HYDROCARBON EVAPORATION PAGE 7

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX		HC	CO	PART
403001071	+	854460.	NEGLIGIBLE	+	.008	NEGLIGIBLE	NEGLIGIBLE
	-	854460.	NEGLIGIBLE	-	.027	NEGLIGIBLE	NEGLIGIBLE
403001500	+	25504000.	NEGLIGIBLE	+	.013	NEGLIGIBLE	NEGLIGIBLE
	-	25504000.	NEGLIGIBLE	-	.013	NEGLIGIBLE	NEGLIGIBLE
403001501	+	1600000.	NEGLIGIBLE	+	.002	NEGLIGIBLE	NEGLIGIBLE
	-	1570000.	NEGLIGIBLE	-	.002	NEGLIGIBLE	NEGLIGIBLE
403001510	+	18000000.	NEGLIGIBLE	+	.009	NEGLIGIBLE	NEGLIGIBLE
	-	18000000.	NEGLIGIBLE	-	.009	NEGLIGIBLE	NEGLIGIBLE
403001511	+	18000000.	NEGLIGIBLE	+	.009	NEGLIGIBLE	NEGLIGIBLE
	-	18000000.	NEGLIGIBLE	-	.009	NEGLIGIBLE	NEGLIGIBLE
403001520	+	18000000.	NEGLIGIBLE	+	.009	NEGLIGIBLE	NEGLIGIBLE
	-	18000000.	NEGLIGIBLE	-	.009	NEGLIGIBLE	NEGLIGIBLE
403001521	+	18000000.	NEGLIGIBLE	+	.009	NEGLIGIBLE	NEGLIGIBLE
	-	18000000.	NEGLIGIBLE	-	.009	NEGLIGIBLE	NEGLIGIBLE
403002000			NEGLIGIBLE	+	.137	NEGLIGIBLE	NEGLIGIBLE
			NEGLIGIBLE	-	.128	NEGLIGIBLE	NEGLIGIBLE
403002010	+	7001800.	NEGLIGIBLE	+	.047	NEGLIGIBLE	NEGLIGIBLE
	-	2920000.	NEGLIGIBLE	-	.019	NEGLIGIBLE	NEGLIGIBLE
403002011	+	7001800.	NEGLIGIBLE	+	.047	NEGLIGIBLE	NEGLIGIBLE
	-	2920000.	NEGLIGIBLE	-	.019	NEGLIGIBLE	NEGLIGIBLE
403002020	+	0.	+ 0.000	+	0.000	+ 0.000	+ 0.000
	-	0.	- 0.000	-	0.000	- 0.000	- 0.000
403002021	+	0.	+ 0.000	+	0.000	+ 0.000	+ 0.000
	-	0.	- 0.000	-	0.000	- 0.000	- 0.000

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

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                            HYDROCARBON EVAPORATION                            PAGE  8
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)         NOX               HC            CO           PART
403002030    +     7071100.     NEGLIGIBLE    +  .038      NEGLIGIBLE    NEGLIGIBLE
             -     7071100.     NEGLIGIBLE    -  .049      NEGLIGIBLE    NEGLIGIBLE

403002031    +     7071100.     NEGLIGIBLE    +  .038      NEGLIGIBLE    NEGLIGIBLE
             -     7071100.     NEGLIGIBLE    -  .049      NEGLIGIBLE    NEGLIGIBLE

403002040    +    18111000.     NEGLIGIBLE    +  .123      NEGLIGIBLE    NEGLIGIBLE
             -    18111000.     NEGLIGIBLE    -  .117      NEGLIGIBLE    NEGLIGIBLE

403002041    +    18111000.     NEGLIGIBLE    +  .123      NEGLIGIBLE    NEGLIGIBLE
             -    18111000.     NEGLIGIBLE    -  .117      NEGLIGIBLE    NEGLIGIBLE

403002050    +       90448.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -       89700.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE

403002051    +       90448.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -       89700.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE

403002060    +       40311.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -       40311.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE

403002061    +       40311.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -       40311.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE

403002070    +      120930.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -      120930.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE

403002071    +      120930.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
             -      120930.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE


403003000    +      814980.     NEGLIGIBLE    +  .025      NEGLIGIBLE    NEGLIGIBLE
             -      814980.     NEGLIGIBLE    -  .077      NEGLIGIBLE    NEGLIGIBLE

403003020    +      814980.     NEGLIGIBLE    +  .025      NEGLIGIBLE    NEGLIGIBLE
             -      814980.     NEGLIGIBLE    -  .077      NEGLIGIBLE    NEGLIGIBLE
```

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

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                                    HYDROCARBCN EVAPORATION                              PAGE  9

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
 MODIFIED          TACRP                      EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)         NOX              HC              CO           PART

403999000   +    18111000.     NEGLIGIBLE    +  .084      NEGLIGIBLE    NEGLIGIBLE
            -    15000000.     NEGLIGIBLE    -  .069      NEGLIGIBLE    NEGLIGIBLE

403999990   +    18111000.     NEGLIGIBLE    +  .084      NEGLIGIBLE    NEGLIGIBLE
            -    15000000.     NEGLIGIBLE    -  .069      NEGLIGIBLE    NEGLIGIBLE

406001000   +    15906000.     NEGLIGIBLE    +  .152      NEGLIGIBLE    NEGLIGIBLE
            -    14080000.     NEGLIGIBLE    -  .056      NEGLIGIBLE    NEGLIGIBLE

406001010   +    10824000.     NEGLIGIBLE    +  .067      NEGLIGIBLE    NEGLIGIBLE
            -     7900000.     NEGLIGIBLE    -  .049      NEGLIGIBLE    NEGLIGIBLE

406001011   +           0.      + 0.000      + 0.000       + 0.000       + 0.000
            -           0.      - 0.000      - 0.000       - 0.000       - 0.000
406001012   +    10824000.     NEGLIGIBLE    +  .067      NEGLIGIBLE    NEGLIGIBLE
            -     7900000.     NEGLIGIBLE    -  .049      NEGLIGIBLE    NEGLIGIBLE

406001020   +      830410.     NEGLIGIBLE    +  .005      NEGLIGIBLE    NEGLIGIBLE
            -      830350.     NEGLIGIBLE    -  .009      NEGLIGIBLE    NEGLIGIBLE

406001021   +       22574.     NEGLIGIBLE    +  .000      NEGLIGIBLE    NEGLIGIBLE
            -       19999.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE
406001022   +      830110.     NEGLIGIBLE    +  .005      NEGLIGIBLE    NEGLIGIBLE
            -      830110.     NEGLIGIBLE    -  .009      NEGLIGIBLE    NEGLIGIBLE

406001260   +    11595000.     NEGLIGIBLE    +  .134      NEGLIGIBLE    NEGLIGIBLE
            -    11595000.     NEGLIGIBLE    -  .024      NEGLIGIBLE    NEGLIGIBLE

406001261   +           0.      + 0.000      + 0.000       + 0.000       + 0.000
            -           0.      - 0.000      - 0.000       - 0.000       - 0.000
406001262   +    11595000.     NEGLIGIBLE    +  .134      NEGLIGIBLE    NEGLIGIBLE
            -    11595000.     NEGLIGIBLE    -  .024      NEGLIGIBLE    NEGLIGIBLE

406001270   +      835160.     NEGLIGIBLE    +  .024      NEGLIGIBLE    NEGLIGIBLE
            -      835160.     NEGLIGIBLE    -  .006      NEGLIGIBLE    NEGLIGIBLE

406001271   +       91706.     NEGLIGIBLE    +  .001      NEGLIGIBLE    NEGLIGIBLE
            -       91706.     NEGLIGIBLE    -  .000      NEGLIGIBLE    NEGLIGIBLE
```

Table 6-3-b. 1981 HC EVAPORATION UNCERTAINTIES (Continued)

```
                    HYDROCARBCN EVAPORATION                          PAGE 10
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX            HC            CO           PART

406001272   +      830110.       NEGLIGIBLE    +   .024     NEGLIGIBLE    NEGLIGIBLE
            -      830110.       NEGLIGIBLE    -   .006     NEGLIGIBLE    NEGLIGIBLE

406002000   +    36896000.       NEGLIGIBLE    +   .094     NEGLIGIBLE    NEGLIGIBLE
            -    15046000.       NEGLIGIBLE    -   .102     NEGLIGIBLE    NEGLIGIBLE

406002010   +    24016000.       NEGLIGIBLE    +   .013     NEGLIGIBLE    NEGLIGIBLE
            -     6300000.       NEGLIGIBLE    -   .003     NEGLIGIBLE    NEGLIGIBLE
406002020   +    10475000.       NEGLIGIBLE    +   .008     NEGLIGIBLE    NEGLIGIBLE
            -     7000000.       NEGLIGIBLE    -   .003     NEGLIGIBLE    NEGLIGIBLE
406002260   +    24016000.       NEGLIGIBLE    +   .008     NEGLIGIBLE    NEGLIGIBLE
            -     6300000.       NEGLIGIBLE    -   .001     NEGLIGIBLE    NEGLIGIBLE
406002270   +     9899500.       NEGLIGIBLE    +   .092     NEGLIGIBLE    NEGLIGIBLE
            -     9899500.       NEGLIGIBLE    -   .102     NEGLIGIBLE    NEGLIGIBLE
```

marginally profitable to produce; consequently, older plants are not being replaced as they enter obsolescence. On the other hand, trichloroethylene is very photochemically reactive and has been banned from uncontrolled use in many areas. For these reasons, perchloroethylene is expected to emerge as the prominent solvent in the next decade.

6.3.2 Surface Coating

Hydrocarbon emissions from paint and other surface coatings occur during application and result primarily from the evaporation of the thinning agent (solvent). A second source of HC emissions is the film formers called resins. The thinner is in the coating to allow application in the liquid state. Although solid (powder) surface coating has been applied and baked with some success in a few limited applications, it is not expected to serve as a significant substitute for liquid coatings in the near future.

The total quantity of surface coatings used nationwide in 1974 was essentially divided equally between industrial applications and trade or retail sales. Since the trade-sales surface coatings are almost exclusively area source emissions, they were not included in this study.

For a better insight into the source of the surface coating emissions, the SCC numbers were subdivided into types of products such as motor vehicles, appliances, and machinery. In 1972, the sheet, strip, and coil industry and the paper industry each represented the source of about a billion pounds of HC discharged to the atmosphere. Motor vehicles and fabric treatment plants each contributed about 0.4-billion pounds. All other activities combined contributed less than 10 percent of the emissions from surface coatings. The emissions from industrial surface coatings come from approximately 10,000 point sources which are widespread geographically.

At the start of this study, no activity had been assigned by the NEDS to the SCC numbers 402002xx nor 402007xx. For this study, these numbers were respectively assigned to paper products and fabric treatment. In the meantime (December 1975), the SCC category number 402007xx was assigned by EPA to adhesives. This represents the only inconsistency between the NEDS numbering system and the modified SCC system described in Table 6-1.

A more detailed description of the industrial surface coating industry is found in Ref. 6-3.

6.3.3 Petroleum Product Storage

Although many types of storage facilities have been developed to retard the loss of petroleum products to the atmosphere, three types store significant quantities of product and were consequently considered in this study: (1) fixed-roof tank, (2) floating-roof tank, and (3) variable vapor-space tank.

According to Ref. 6-1, five products are significant contributors (≥500 tons per year) to atmospheric emissions: (1) gasoline, (2) crude oil, (3) jet fuel (JP-4), (4) kerosene, and (5) distillate fuel.

Although all five fluids contributed to emissions from fixed-roof and floating-roof tanks, only gasoline was found to be a significant emitter of vapor from the variable vapor-space tank. Reference 6-4 describes the causes of and influencing factors on evaporation from petroleum product storage tanks. Although initial motives for developing the floating-roof and variable vapor-space tanks were essentially economic through conservation of the products, pollution alleviation characteristics are inherent. Recent improvements have been directed toward the pollution control aspects of these facilities.

The American Petroleum Institute (API) coordinated efforts as early as 1952 to correlate evaporation losses to tank and fluid variables. Empirically derived equations which relate the evaporative losses to the independent variables for the fixed-roof, floating-roof, and variable vapor-space tanks are respectively described in Refs. 6-5 through 6-7.

For purposes of emissions data, storage, and handling, as in Refs. 6-1 and 6-2, emissions from the storage tanks are calculated from an equation which is a function only of two variables, the emission factor and the charge rate as defined in Table 6-1. Reference 6-8 lists the EPA-recommended emission factors. To capitalize on the API analysis, it was necessary to convert the API empirically derived equations into the two-variable equation. This was accomplished by rearranging the API equations as necessary to include the Table 6-1 charge rate as one of the variables. For example, the API breathing loss equation is a function of tank diameter to the 1.73 power and the average vapor space depth to the 0.51 power, which in turn are related to tank capacity. Through proper substitution, the tank capacity (which is the Table 6-1 charge rate) can appear in the API equation. The product of all other terms in the API equation corresponds to the emission factors. If nominal values are assigned to these terms, an emission factor can be calculated which corresponds to the nominal conditions. Section 6.5 describes the development of the modified API equation for the subject evaporation losses.

6.3.4 Marketing and Transportation of Petroleum Products

6.3.4.1 Point Source Emissions

Significant loss of HC vapors to the atmosphere is encountered in two of the operations involved in marketing and transportation of petroleum products. These two operations are (1) loading railraod tank cars and tank trucks and (2) loading and unloading of marine vessels.

6.3.4.2 Area Source Emissions

Although large quantities of HC emissions are attributed to unloading tank trucks and filling motor vehicles at retail service stations, none dispense sufficient quantities to qualify as a point source. To qualify as a point source emission (≥100 tons/year) with 1975 emission factors (~ 10 lb/1000 gal transferred), filling stations would have to pump approximately 20-million gal/year. Although NEDS lists 45 stations under the broad heading of vapor displacement sources (4-06-004-01), the composite total annual charge rate from these sources is only 4.593-million gal. Also, a personal communication with a representative of Standard Oil Company, El Segundo, California, indicated that the rates of their higher filling stations are 160,000-gal/month (~ 2-million gal/year). It was concluded that no filling stations qualify as point sources. Table 6-4 lists the HC emission losses at service stations.

6.4 EMISSIONS ANALYSIS

This section describes certain of the hypotheses, assumptions, and observations that were made in the course of establishing the data base on which the charge rate and emission rate calculations are based.

6.4.1 Cleaning Solvents

The change in charge rate (tons of clothing per year) for the dry cleaning processes reflects two things:

a. The phasing out of petroleum solvent is assumed to be completed in a 10-year period starting in 1972. The synthetic solvent is expected to fill this void.

b. The expected annual population growth rate is 0.9 percent from 1972 to 1980.

The degreasing sector of cleaning solvent usage is also under scrutiny, and the distribution of usage rates among the four major solvents is expected to be realigned. The Stoddard solvent is expected to disappear from the market because petroleum companies are not replacing antiquated facilities for reasons of poor profit forecasts. Also, trichloroethane and trichloroethylene uses are expected to be restricted to operations where emissions are highly controlled. These solvents are highly photochemically reactive. Perchloroethylene is expected to make up the deficit created by the declining use of these two solvents.

The general industrial usage rate of solvents is also expected to increase by 3 percent per year, which is the typical growth rate of manufactured goods over the last 10 years. This growth is also factored into the perchloroethylene and miscellaneous solvent usage rate change.

Table 6-4. EVAPORATION FROM SERVICE STATIONS: GASOLINE TRANSFERRED CHARGE RATES AND EMISSIONS

MSCC	Gasoline Pumped, 1000 gal/yr		HC Emissions, million tons/yr		Activity
	1976	1981	1976	1981	
A406004011	5.69E7	5.69E7	0.138	0.023	Vapor displacement during fill
A406004012	3.56E7	3.56E7	0.094	0.016	Vapor displacement during fill
A406004013	9.14E6	9.14E6	0.040	0.040	Vapor displacement during fill
Total Sales	1.016E8	1.016E8	0.272	0.079	
A406004020	1.016E8	1.016E8	0.006	0.005	Spillage
Total			0.278	0.084	
A406003010	5.772E7	-0-	0.332	-0-	Filling underground storage
A406003020	3.902E6	1.040E7	0.014	0.038	Filling underground storage
A406003030	1.532E7	4.080E7	0.006	0.016	Filling underground storage
A406003040	2.401E7	5.040E7	-0-	-0-	Filling underground storage
Total Storage	1.016E8	1.016E8	0.352	0.054	
Total Service Station Activity			0.630	0.138	

6.4.2 Surface Coating

Except for motor vehicles, the 1972 data in Ref. 6-3 were used to establish the baseline values for charge rates (quantity of surface coating used) and the emission factors (percent of surface coating comprised by solvent) from which projections were made.

Although the data published in Ref. 6-9 are based on a sample survey and the actual usage numbers may be somewhat different from the published numbers, the percentage changes per year are considered accurate. For this reason, the Ref. 6-9 data were used as a basis for establishing the slope and slope uncertainty of the time-usage curve of the respective industrial surface coating applications.

Automobile, truck, and bus production data extracted from Refs. 6-10 and 6-11 were the basis for estimating vehicle production and paint usage rates.

Reference 6-12 listed 26 lb of paint and other surface coating as being used on the Plymouth Fury, which is considered an average passenger car. Bus and truck usages were estimated on the basis of their relative surface area to the passenger car area.

6.4.3 Petroleum Product Storage

The API equations are intended for calculating the evaporative emissions under a particular set of storage conditions. At this writing, an inventory of facilities grouped according to the various influencing parameters is not available. Hence, an emission factor was determined for each tank type and stored fluid on the basis of a set of conditions that are considered typical. For example, for gasoline stored in a fixed-roof tank, the breathing losses might be calculated by means of the following typical parameters:

Storage Temperature	63°F
Average Daily Temperature Excursion	15°F
True Vapor Pressure	5.8 psia
Density	6.2 lb/gal

Paint Factor	1.14
Tank Depth	48 ft
Tank Diameter	110 ft
Factor for Liquid Stored (Gasoline)	0.024

Although the above variables may be typical (average) for fixed-roof gasoline storage, the real nationwide emissions as calculated by summing the emissions from individual tanks using the API equations do not equal the emissions calculated from the EPA equations using an emission factor based on the above typical values. The exact error is dependent on the distribution and range of variation of the independent variables. This error also results from the nonlinear effects of certain independent variables.

Section 6.6 shows the error due to distribution of tank geometry in calculated emissions using the EPA equation and a specific distribution and range of variation of tank diameter and height for fixed-roof gasoline tanks. Although the distribution of the independent variables used in Section 6.6 is highly unusual, it is intended to show the maximum error for the one emission factor concept. In addition to this error, an error in emission calculated for a group of tanks results of the true average of a particular independent variable was different from the assumed value. Section 6.7 shows the effect of using an emission factor based on one set of conditions when another set prevails.

The uncertainty of the emission factor was established either as (1) 10 percent of the nominal level, or (2) the difference between the emission factor listed in Ref. 6-8 and the one calculated from typical variables using the equation developed in Section 6.5, whichever was greater. This represents an overall uncertainty, i.e., the composite effect of the uncertainty of the individual parameters is reflected in the emission factor uncertainty.

According to Ref. 6-13, the stocks of gasoline at the end of the year have been essentially the same for the past six years. Since the total storage capacity is a linear function of the average stock on hand (which is based on politically decided reserves), no change in total gasoline capacity is forecast, at least through 1980. Based on a private communication with Standard Oil of California personnel, it appears that the use of fixed-roof storage tanks for gasoline may disappear as early as 1980. It is estimated that approximately 20 percent of the storage loss will be made up by floating-roof tanks and the remainder by variable vapor-space systems. The distribution of gasoline storage capacity among the three types of tanks is necessary for breathing loss calculations.

Although the number of motor vehicles (as well as total vehicle miles traveled) is expected to increase well beyond 1980, the estimated gasoline demand for highway usage is expected to remain near 100-billion gal/year. The primary reason that consumption is likely to remain constant while the car population increases is the improved mileage of current and future autos. Therefore, in estimating the working vapor losses of gasoline, the total throughput is considered constant with 80 percent of fixed-roof throughput being replaced by floating-roof facilities and 20 percent by variable vapor-space systems.

The floating-roof tanks will take over the majority of the gasoline throughput formerly handled by the fixed-roof tanks because of their superior control of HC emissions during filling and while empty. The variable vapor-space system breathing losses during static storage are near zero and consequently will represent about 60 percent of the gasoline storage capacity by 1981.

6.4.4 Marketing and Transportation of Petroleum Products

Point source emissions in 1976 from marketing and transportation of petroleum products are principally from operations involving the splash loading of gasoline on tank trucks (0.14-million tons/year of HC and the unloading of crude from marine vessels (0.09-million tons/year of HC). Emissions from these sources are expected to be reduced to 0.05-million tons/year and increased to 0.2-million tons/year of HC vapors, respectively, in 1981. Both activities will have lower emission factors in 1981, primarily through the implementation of vapor control techniques, such as use of the submerged fill pipe. For example, for gasoline loading, the emission factor with a submerged fill pipe is about one third as great as with the splash fill. Although the vapor recovery system (either balance or vacuum assist) potentially can capture and retain between 90 and 100 percent of the vapors formed, few systems have been installed where the transfer is potentially from any one of several sources or to one of several receptacle tanks. This is in contrast to the system used in filling underground storage tanks at filling stations which cycles the vapors from the tank to the truck through the annular coax line, which is integrated with the fill line.

Since no distinction was made between the petroleum movement by tank trucks and railroad tank cars in the NEDS SCC system, The Aerospace Corporation MSCC was adapted with a "1" in the 10th digit for railroad tank cars and a "2" for tank trucks (motorized vehicles for highway usage).

According to Ref. 6-14, the movement of gasoline by rail is on the decline. Should the trend continue, that form of gasoline movement may disappear by the early 1980s. That trend, coupled with some implementation of emission control measures, indicates that emissions from the loading of gasoline onto railroad cars (both splash and submerged) may be near zero by 1981.

Although the movement of crude by rail has experienced many ups and downs in the last decade, the trend seems to reflect a constant usage rate. The splash loading technique is expected to be replaced by submerged loading of crude.

The total petroleum loading movement (both gasoline and crude) was apportioned between splash and submerged according to the split that was reflected in the NEDS data.

6.5 EMISSION FACTORS DERIVED FROM API ANALYSIS

In order that emission factors might be derived (or confirmed) for evaporative losses from petroleum storage tanks, empirically derived equations from the API analysis described in Refs. 6-5 through 6-7 are utilized. Values for the terms can be found in the respective references when emissions are to be determined for specific conditions.

6.5.1 Fixed-Roof Breathing Losses

The API equation for fixed-roof breathing losses is taken from Ref. 6-5:

$$Ly = C\left(\frac{P}{14.7-P}\right)^{0.68} D^{1.73} H^{0.51} \Delta T^{0.50} F_p \qquad (6\text{-}1)$$

where:

L_y = breathing loss (bbl/year)

C = adjustment factor for small tanks (C = 100 for D ≥ 30 ft)

P = true vapor pressure based on average bulk temperature (psia)

D = tank diameter (ft)

H = average vapor space depth (ft)

ΔT = average daily ambient temperature excursion (maximum minus minimum)(°F)

F_p = paint factor (no dimensions): 1.00 for all-white tank with paint in good condition.

The following definitions apply:

$$V = \frac{\pi D^2}{4} d \qquad \text{or} \qquad D^2 = \frac{4V}{\pi d} \qquad (6\text{-}2)$$

$$D^{1.73} = \frac{D^2}{D^{0.27}}$$

$$D^{1.73} = \frac{4V}{\pi d D^{0.27}} \qquad (6\text{-}2a)$$

$$Q = 7.48 \times 10^{-3} V \qquad (6\text{-}3)$$

$$E = L_y \times 42 \text{ (gal/bbl)} \times \rho \qquad (6\text{-}4)$$

and the following assumption was made:

$$H_{\text{average}} = 0.5\, d \qquad (6\text{-}5)$$

where

V = tank volume capacity (cu ft)
d = equivalent height of cylindrical volume (ft)
Q = tank volume capacity (1000 gal)(SCC units)
E = evaporative loss by breathing (lb/year)
ρ = liquid density at average bulk temperature (lb/gal)

Substituting definitions of Eqs. (6-2a), (6-3), and (6-4) and the assumption, Eq. (6-5), into the API equation, Eq. (6-1), for breathing losses yields:

$$E = \left[5020.33\, \rho C \left(\frac{P}{14.7 - P} \right)^{0.68} \frac{\sqrt{\Delta_T}\; F_p}{d^{0.49} D^{0.27}} \right] Q \qquad (6\text{-}6)$$

where the product of terms in the brackets represents the emission factor in (lb/yr)/1000-gal capacity:

$$E = EF \times Q \qquad (6\text{-}7)$$

which is the EPA equation form.

6.5.2 Fixed-Roof Working Losses

The API equation for fixed-roof working losses is also taken from Ref. 6-5:

$$F = CPVK_t \tag{6-8}$$

where

C = factor dependent on liquid stored

P = true vapor pressure based on average bulk temperature (psia)

V = annual throughput (bbl/year)

K_t = turnover factor (dimensionless)

F = working loss (bbl/year)

The following definitions apply:

$$V = Q \times \left(\frac{1000}{42}\right) \tag{6-9}$$

$$E = F \times 42 \times \rho \tag{6-10}$$

where

E = working loss (lb/year)

Q = annual throughput (1000 gal/year)

ρ = density of liquid at average bulk temperature (lb/gal)

Substituting Eqs. (6-9) and (6-10) into the API equation, Eq. (6-8), for working losses yields:

$$E = \left[1000\ C\rho P\ K_t\right]Q \tag{6-11}$$

where the product of terms in the brackets represents the emission factor in (lb/year)/1000-gal throughput.

6.5.3 Standing Losses from Floating-Roof Tanks

The API equation for standing losses from floating-roof tanks is taken from Ref. 6-6:

$$L_y = K_t K_s K_c K_p D^{1.5} \left(\frac{wP}{14.7 - P} \right)^{0.7} \qquad (6\text{-}12)$$

where

L_y = standing loss (bbl/year)
K_t = tank-type factor
K_s = seal factor
K_c = fluid factor
K_p = paint factor
D = tank diameter (ft)
(for $D > 150$, replace $D^{1.5}$ with $12.25D$)
w = average wind velocity (mph)

The following definitions apply:

$$D^{1.5} = \frac{4V}{\pi d \sqrt{D}} \qquad (6\text{-}13)$$

$$V = \frac{1000}{7.48} Q \qquad (6\text{-}14)$$

$$E = 42 \times \rho \times L_y \qquad (6\text{-}15)$$

where

V = volumetric capacity (cu ft)
Q = volumetric capacity (1000/gal)
d = equivalent cylindrical depth of the tank (ft)
ρ = liquid density (lb/gal) at average bulk temperature

Substituting Eqs. (6-13) through (6-15) into the API equation, Eq. (6-12), yields:

$$E = \left[\frac{7149\ \rho K_t K_s K_c K_p}{\sqrt{D}\ d} \left(\frac{wP}{14.7 - P}\right)^{0.7}\right] Q \qquad (6\text{-}16)$$

where the product of terms in the brackets represents the emission factor in (lb/year)/1000-gal capacity.

6.5.4 Working Losses from Floating-Roof Tanks

API developed a clingage factor, c, which reflects the barrels of liquid per 1000 ft which cling to the wall and are exposed to the atmosphere to evaporate during a withdrawal process, when the floating roof slides down with the liquid surface.

This results in the following API emissions equation (Ref. 6-6):

$$E = (22.46\ c\rho)Q \qquad (6\text{-}17)$$

where

c = clingage factor (bbl/1000 sq ft of wetted wall surface)
ρ = liquid density at average bulk temperature (lb/gal)
Q = petroleum product withdrawn (1000 gal/year)
E = emissions (lb/year)

6.5.5 Working Losses from Variable Vapor-Space Tank Systems

Except for unplanned leakage, no vapor is lost to the atmosphere from variable vapor-space systems until vapor volume tends to exceed the expansion capacity of the system; then it behaves essentially like a fixed-roof storage facility. This is the basis for the equation which determines the emission from the variable vapor-space system. The only difference from the fixed-roof working losses is that the throughput term Q of Eq. (6-11) becomes only that throughput which exceeds the available expansion remaining at the start of the fill operation.

Let Q in Eq. (6-11) be replaced by ΔQ where ΔQ is defined as the volume of liquid transferred after the vapor expansion system reached its limit. Another way to express ΔQ is the difference between the total liquid transferred and the expansion capability remaining at the start of the operation.

To further simplify the referenced equation, three assumptions are made that represent the average system and its operation:

a. Available expansion volume at the start of the operation is one-fourth the total expansion capability of the system.

b. Each transfer involves a complete turnover; i.e., the quantity transferred equals the capacity of the tank.

c. Expansion capacity equals three-fourths of total liquid capacity of the tank.

The following equation represents the emissions expelled during filling operations of the variable vapor space:

$$E = (810\ C\rho P)Q \tag{6-18}$$

where

E = emissions (lb/yr)
C = factor dependent on liquid stored
ρ = density of liquid at average bulk temperature (lb/gal)
P = true vapor pressure based on average bulk temperature (psia)
Q = annual throughput (1000 gal/yr)

Reference 6-7 describes the variable vapor space system in greater detail.

Since the expansion capacity is seldom exceeded while the system is in a standby mode, the breathing loss is considered negligible.

6.6 COMPARISON OF API AND EPA EMISSION EQUATIONS

Unless an extensive expansion of the SCC system is effected, one emission factor (EF) value must be used for a broad range of variables. Use of the EPA equation, which is a simplified version of the API equation, introduces an error in the calculated emission. The limits of this error can be determined from a comparison of the breathing losses of a group of fixed-roof gasoline storage tanks calculated from the API and EPA equations, respectively. The population of tanks is made up of two subgroups, one with diameters that are 0.90 and the other 1.1 of the average diameter. Both subgroups have an equal number n in the set. Although this is a highly unusual distribution, it was selected for the comparison to show the upper limit of the error. All other variables are the same for the entire group. A similar comparison is made for varying depth.

From Section 6.5.1, the API equations yield the following emissions in terms of D (average tank diameter) and Q, the capacity of the tank with an average diameter D:

$$E = n \times 42\, \rho C \left(\frac{P}{14.7 - P}\right)^{0.68} H^{0.51} \sqrt{\Delta T}\, F_p \times \left[(0.9D)^{1.73} + (1.1D)^{1.73}\right] \tag{6-19}$$

Factoring $D^{1.73}$ and substituting the following

$$\begin{aligned} Q &= 7.481 \times 10^{-3}\, V \\ &= 7.481 \times 10^{-3} \left(\frac{\pi D^2}{4} \times d\right) \end{aligned} \tag{6-20}$$

or rearranging

$$D^{1.73} = \frac{4Q}{7.481 \times 10^{-3}\, dD^{0.27} \pi} \tag{6-21}$$

and letting

$$H = 0.5\ d \tag{6-22}$$

and

$$EF = \frac{5020.3\ F_p \rho c}{d^{0.49}\ D^{0.27}} \left(\frac{P}{14.7 - P}\right)^{0.68} \sqrt{\Delta T} \tag{6-23}$$

then, it is found that

$$\begin{aligned} E &= n \times EF \times Q \left(0.9^{1.73} + 1.1^{1.73}\right) \\ E &= 2.01 \times n \times EF \end{aligned} \tag{6-24}$$

The EPA emission equation is simply the product of an emission factor EF and the tank capacity. Although the emissions can be calculated for each tank using its particular capacity, no provisions exist for adjusting the emission factor from tank to tank even though it is a function of tank diameter. Instead the emissions from a group of tanks are calculated from some representative emission factor based on a typical set of independent variables, such as an average diameter of the group.

The EPA emission equation yields the following emissions for a group of 2n tanks, using an emission factor EF based on the average diameter D:

$$\begin{aligned} E &= n \times EF \times \left[\frac{\pi(0.9D^2)\ d}{4} + \frac{\pi(1.1D^2)\ d}{4}\right] \\ &= n \times EF \times \frac{\pi D^2 d}{4} (0.9^2 + 1.1^2) \\ &= n \times EF \times Q\ (0.9^2 + 1.1^2) \\ &= n \times EF \times Q \times 2.02 \end{aligned} \tag{6-25}$$

The ratio of true emissions to those calculated from an emission factor based on an average diameter is 2.01/2.02 or 0.995, i.e., about a 0.5 percent error.

If the diameters of the two tank groups are 0.5 and 1.5 of the average diameter, the true to indicated emission is 2.318/2.506 or 0.927, i.e., about a 7.3 percent error.

A similar comparison is made for tank depth:

$$E = \frac{K}{(0.9d)^{0.49}} \times n \times 0.9\,Q + \frac{K}{(1.1d)^{0.49}} \times n\, 1.1\,Q$$

$$= EF \times Q \times n \left(0.9^{0.51} + 1.1^{0.51}\right) \qquad (6\text{-}26)$$

$$= 1.997 \times EF \times n \times Q$$

The EPA equations then yield the following:

$$E = EF \times Q \times n \times (0.90 + 1.10)$$

$$= 2.00 \times EF \times Q \times n \qquad (6\text{-}27)$$

The ratio of true to indicated emissions is 1.997/2.000 or 0.999, i.e., about a +0.1 percent error.

For the 0.5 and 1.5 depth ratios, the true to indicated emission ratio is 1.932/2.000 or 0.966, i.e., about a +3.4 percent error.

6.7 ERROR OF EMISSION FACTORS BASED ON API ANALYSIS

The API equations for vapor loss from petroleum tanks express the emissions as functions of several independent variables to a variety of powers. These equations are given in Section 6.5.

The effect of calculating the emissions from a system of tanks while using a value different from the effective or true value of certain variables is presented in Tables 6-5 through 6-8 and in Figures 6-1 through 6-4 for fixed-roof breathing losses. The API equation for fixed-roof breathing losses is as follows:

$$L_y = C\left(\frac{P}{14.7 - P}\right)^{0.68} D^{1.73} H^{0.51} \Delta T^{0.5} F_p \qquad (6\text{-}28)$$

The symbols and terms used in Eq. (6-28) and in Tables 6-5 through 6-8 are defined in Section 6.5.

6.8 REFERENCES

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6-12. Technological Improvements to Automobile Fuel Consumption, TSC-OST-74-39, Vol. II-A, U.S. Department of Transportation, Washington, D.C., prepared by the Southwest Research Institute (December 1974).

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Table 6-5. VAPOR PRESSURE EFFECTS ON FIXED-ROOF BREATHING LOSSES

Vapor Pressure P_i[a]	$\left(\frac{P}{14.7 - P}\right)^{0.68}$	Ratio of Emissions E_i/E_B (Case of Interest ÷ Baseline Case)[a]			
		$P_B = 1$	$P_B = 2$	$P_B = 4$	$P_B = 6$
0.5	0.103	0.609			
1.0	0.169	1.000	0.593		
1.5	0.228	1.349	0.800		
2.0	0.285	1.686	1.000	0.557	
3.0	0.396		1.389	0.773	0.510
4.0	0.512		1.796	1.000	0.659
6.0	0.777			1.504	1.000
8.0	1.128			2.203	1.452

[a] Terms subscripted with "i" correspond to case of interest; terms subscripted with "B" correspond to baseline case.

Table 6-6. DIAMETER EFFECTS ON FIXED-ROOF BREATHING LOSSES

Diameter D_i[a]	C	$D^{1.73}$	$C \times D^{1.73}$	Ratio of Emissions E_i/E_B (Case of Interest ÷ Baseline Case)[a]				
				$D_B = 10$	$D_B = 30$	$D_B = 60$	$D_B = 110$	$D_B = 170$
6	0.30	22.19	6.66	0.248				
8	0.40	36.50	14.60	0.544				
10	0.50	53.70	26.85	1.000	0.075			
11	0.55	63.35	34.83	1.297	0.097			
12	0.60	73.62	44.17	1.645	0.123			
14	0.70	96.12	67.28	2.506	0.187			
20	0.88	178.15	156.77	5.839	0.436			
30	1.00	359.27	359.27		1.000	0.301		
40	1.00	590.97	590.97		1.645	0.496		
60	1.00	1191.80	1191.80			1.000	0.350	
80	1.00	1960.40	1960.40			1.645	0.576	
110	1.00	3401.02	3401.02			2.854	1.000	0.471
140	1.00	5161.80	5162.00				1.518	0.715
170	1.00	7222.32	7222.00				2.123	1.000
210	1.00	10409.73	10410.00					1.441
250	1.00	14074.60	14075.00					1.949

[a] Terms subscripted with "i" correspond to case of interest; terms subscripted with "B" correspond to baseline cases.

Table 6-7. ULLAGE DEPTH EFFECTS ON FIXED-ROOF BREATHING LOSSES

Ullage Depth H_i[a]	$H^{0.51}$	Ratio of Emissions E_i/E_B (Case of Interest + Baseline Case)[a]			
		$H_B = 5$	$H_B = 10$	$H_B = 20$	$H_B = 25$
2	1.424	0.627			
3	1.751	0.771			
5	2.272	1.000	0.702		
7	2.698	1.188	0.834		
10	3.236	1.424	1.000	0.707	
15	3.979		1.230	0.863	0.771
20	4.608		1.424	1.000	0.892
25	5.164			1.121	1.000
30	5.667			1.230	1.097
35	6.130				1.187

[a] Terms subscripted with "i" correspond to case of interest; terms subscripted with "B" correspond to baseline cases.

Table 6-8. TEMPERATURE EXCURSION EFFECTS ON FIXED-ROOF BREATHING LOSSES

Temperature Excursion ΔT_i^a	$\sqrt{T}$	Ratio of Emissions E_i/E_B (Case of Interest + Baseline Case)[a]				
		$\Delta T_B = 5$	$\Delta T_B = 9$	$\Delta T_B = 15$	$\Delta T_B = 22$	$\Delta T_B = 30$
2	1.414	0.632				
5	2.236	1.000	0.745			
9	3.000	1.342	1.000	0.775		
15	3.873	1.732	1.291	1.000	0.826	
22	4.690		1.563	1.211	1.000	0.856
30	5.477			1.414	1.168	1.000
40	6.325				1.349	1.155
50						1.291

[a] Terms subscripted with "i" correspond to case of interest; terms subscripted with "B" correspond to baseline cases.

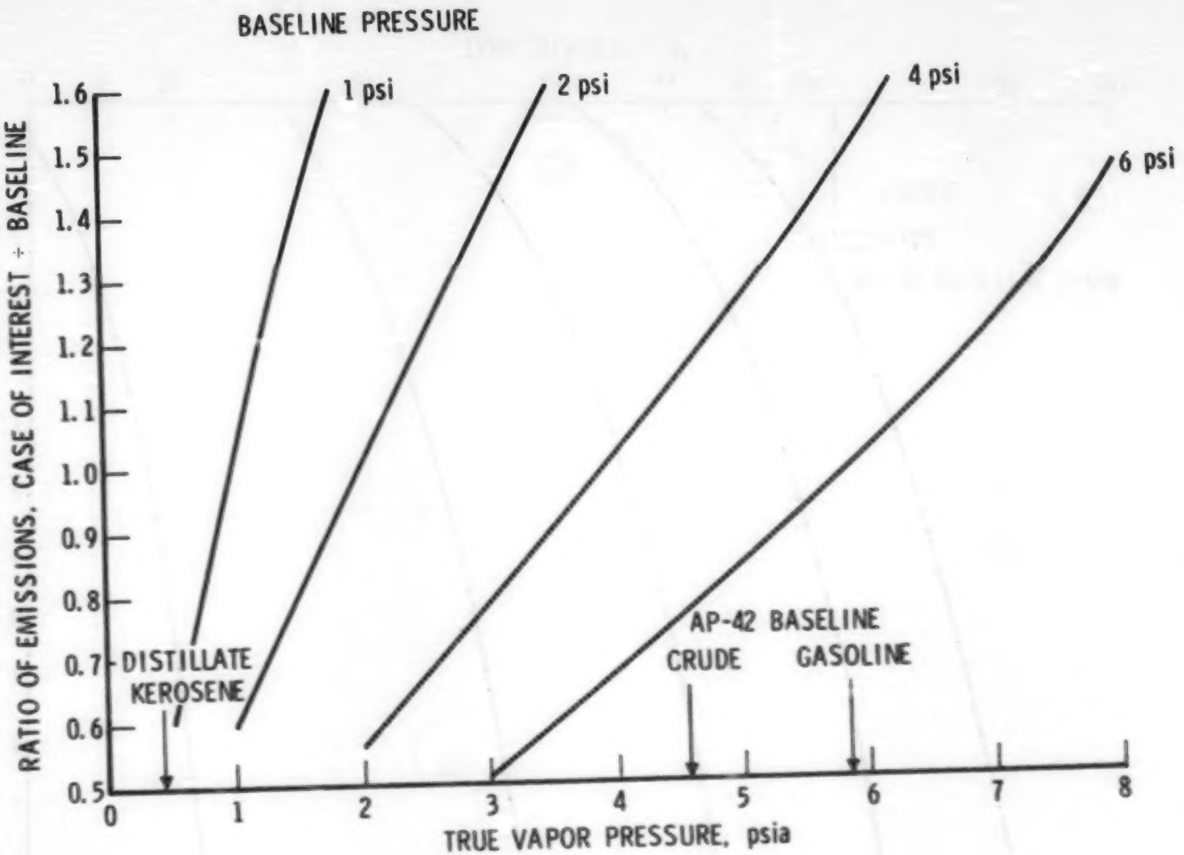

Figure 6-1. Effects of vapor pressure on fixed-roof breathing losses

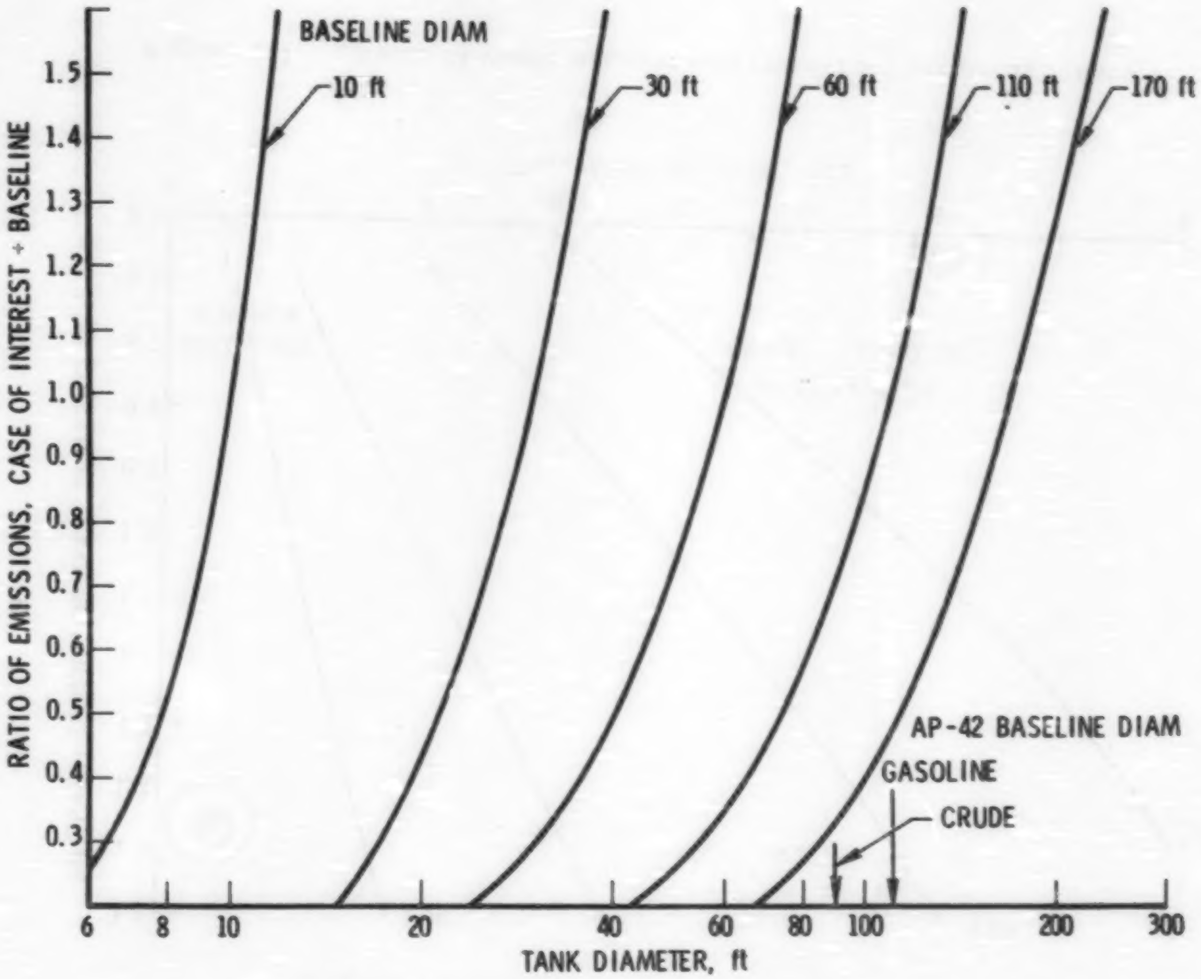

Figure 6-2. Effects of tank diameter on fixed-roof breathing losses

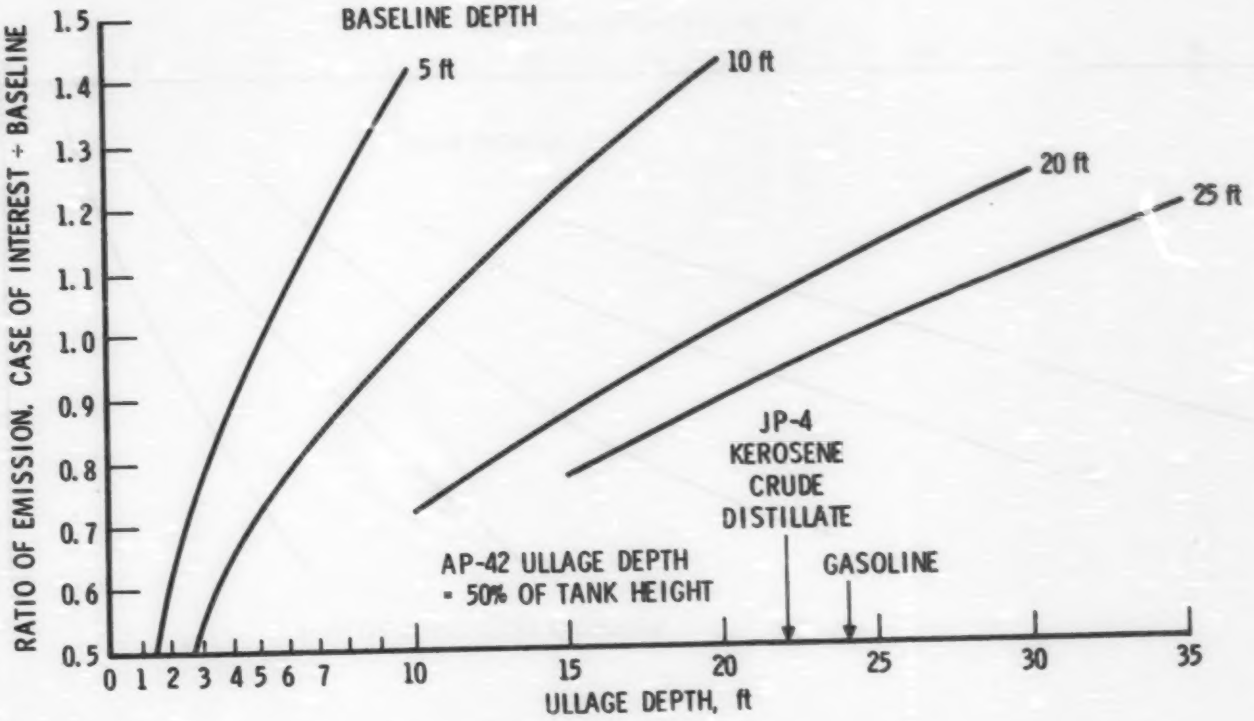

Figure 6-3. Effects of ullage depth on fixed-roof breathing losses

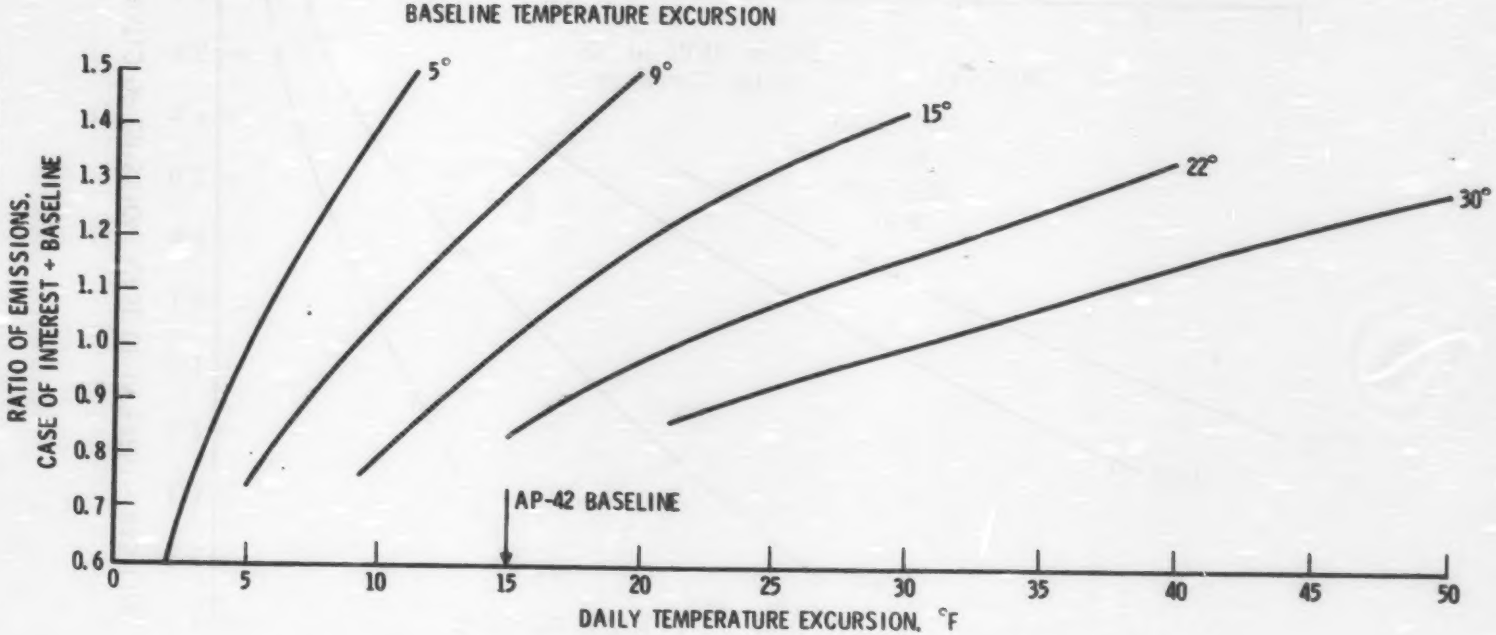

Figure 6-4. Effects of daily temperature excursion on fixed-roof breathing losses

SECTION 7

PRIMARY METALS

7.1 INTRODUCTION

The metallurgical industries are considered to be part of the industrial processes category of the National Emissions Data System (NEDS) source classification coding system. The primary metals industry uses ore for its production, while the secondary metals industry primarily uses scrap metal. The Source Classification Code (SCC) number which represents the primary metals industry is 3-03-xxx-xx.

Table 7-1 describes the metallurgical processes studied and gives the corresponding modified SCC (MSCC) numbers and annual charge (or usage) rate units. The study list was formed from those primary metal processes which had one or more of the four pollutants of interest with an emission rate greater than 500 tons/year according to Ref. 7-1. The four pollutants of interest in the study are oxides of nitrogen (NO_x), hydrocarbon (HC), carbon monoxide (CO), and particulate matter (PART). Except for a few isolated cases, the only significant quantities of emissions from the primary metals industry are CO and PART.

7.2 SUMMARY

The annual CO emissions from the primary metals industries in 1976 were 11-1/3 million tons compared to about 37-2/3 million tons from all stationary point sources. These are principally from blast furnaces (6×10^6 tons) and basic oxygen furnaces (4×10^6 tons) used, respectively, for pig iron and steel production. In 1981, the CO from primary metals is expected to be reduced to 6-2/3 million tons through the implementation of improved control techniques.

The PART emissions from the primary metals industry in 1976 were nearly 3.6-million tons. The estimated nationwide total PART emissions in 1975 from stationary point sources were 13.5-million tons.

The estimated 1981 PART emission rate from primary metals is 0.86-million tons. Most of this reduction is attributed to the improved control techniques which are forecast for copper smelters.

A detailed list of emissions and charge rate data is listed in Tables 7-2 and 7-3 for the years 1976 and 1981, respectively.

7.3 PROCESSES EVALUATED

A total of 72 primary metal processes is listed in the NEDS data bank (Ref. 7-1). Fifty-two were found to show 500 or more tons of at least one of the four emissions of interest. Although the year of effectivity was between 1971 and 1973, these 52 categories were considered potential contributors to air pollution in 1976 and 1981 and therefore served as the basis for selection of the primary metal operations to be studied. A brief description of the most significant emitters of CO and PART follows.

7.3.1 Blast Furnace and Related Operations

Blast furnaces are used to produce pig iron by packing coke, iron ore, and limestone into brick-lined chamber. Much of the carbon is reacted to CO_2 (10 percent of blast furnace gas), but substantial quantities of CO (27 percent) are generated. From 1300 to 1800 lb of CO are generated for each ton of pig iron produced. Much of the CO produced is collected, cleaned of PART, and burned as a secondary fuel in the steel mill. Although the blast furnace gas (mostly CO) has a heat content of about 100 Btu/cu ft, its use as a fuel is secondary, in this study, to the emission control aspects of the burning.

(Continued on page 7-22)

Table 7-1. DEFINITION OF PRIMARY METALS PROCESSES

MSCC	Source Category	Charge Rate Unit
303001000	Aluminum electrode reduction	Aluminum, tons/yr
303001010	Prebake cells	Aluminum, tons/yr
303001020	Horizontal stud soderberg	Aluminum, tons/yr
303001030	Vertical stud soderberg	Aluminum, tons/yr
303001040	Materials handling	Aluminum, tons/yr
303001050	Anode bake furnce	Aluminum, tons/yr
303001990	Other, not classified	Aluminum, tons/yr
303002000	Aluminum ore calcined	Aluminum, tons/yr
303002010	General	Aluminum, tons/yr
303003000	Coke metallurgical byproduct	Coal, tons/yr
303003010	General	Coal, tons/yr
303003020	Oven charging	Coal, tons/yr
303003030	Oven pushing	Coal, tons/yr
303003040	Quenching	Coal, tons/yr
303003050	Unloading	Coal, tons/yr
303003990	Other, not classified	Coal, tons/yr
303004000	Coke beehive	Coal, tons/yr
303004010	General	Coal, tons/yr
303005000	Copper smelter	a
303005020	Roasting	Copper, tons/yr
303005030	Smelting	Copper, tons/yr
303005040	Converting	Copper, tons/yr
303005050	Refining	Copper, tons/yr
303005060	Ore crushing, material handling, and miscellaneous activity	Copper, tons/yr
303005990	Other, not classified	Ore, tons/yr

Table 7-1. DEFINITION OF PRIMARY METALS PROCESSES (Continued)

MSCC	Source Category	Charge Rate Unit
303006000	Ferroalloy production, open furnace	Produced, tons/yr
303006010	50% ferrosilicon	Produced, tons/yr
303006020	75% ferrosilicon	Produced, tons/yr
303006030	90% ferrosilicon	Produced, tons/yr
303006040	Silicon metal	Produced, tons/yr
303006050	Silicomanganese	Produced, tons/yr
303006990	Other, not classified	Produced, tons/yr
303007000	Ferroalloy production, semi-covered furnace	Produced, tons/yr
303007010	Feromanganese	Produced, tons/yr
303007020	General	Produced, tons/yr
303008000	Iron production	a
303008010	Blast furnace charge	Produced, tons/yr
303008020	Blast furnace, aggolmerates change	Produced, tons/yr
303008030	Sintering general	Produced, tons/yr
303008040	Ore-crush, handle	Ore, tons/yr
303008050	Scarfing	Processed, tons/yr
303008060	Sand handling operation	Sand-baked, tons/yr
303008990	Other, not classified	Produced, tons/yr
303009000	Steel production	Produced, tons/yr
303009010	Opnhearth oxlance	Produced, tons/yr
303009020	Opnhearth noxlance	Produced, tons/yr
303009030	Basic oxygen furnace (general)	Produced, tons/yr
303009040	Electric arc with lance	Produced, tons/yr

Table 7-1. DEFINITION OF PRIMARY METALS PROCESSES (Continued)

MSCC	Source Category	Charge Rate Unit
303009050	Electric arc, no lance	Produced, tons/yr
303009990	Other, not classified	Produced, tons/yr
303010000	Lead smelters	a
303010010	Sintering	Ore, tons/yr
303010020	Blast furnace	Ore, tons/yr
303010990	Other, not classified	Ore, tons/yr
303011000	Molybdenum	a
303011010	Mining, general	Mined, 100 tons/yr
303011020	Milling, general	Product, tons/yr
303011990	Process, other	Processed, tons/yr
303012000	Titantium processes	a
303012010	Chlorination stat	Product, tons/yr
303030000	Zinc smelting	Processed, tons/yr
303030010	General	Processed, tons/yr
303030040	Horizontal retorts	Processed, tons/yr
303999000	Miscellaneous metallurgical operations	Processed, tons/yr
303999990	Not elsewhere classified	Produced, tons/yr

[a] This represents a collection of processes whose charge rate units are different from one another.

Table 7-2-a. 1976 PRIMARY METALS EMISSIONS AND CHARGE RATES

INDUSTRIAL PROCESS, PRIMARY METALS PAGE 1

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
303000010	19660000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.006
303001000	22082000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.115
303001010	2491000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.033
303001020	1124000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.030
303001030	991000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.013
303001040	3450000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.006
303001050	1426000.	0.000	0.000	0.000	.000
303001990	12600000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.034
303002000	8964000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.045
303002010	8964000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.045
303003000	458400000.	.002	.184	.056	.088
303003010	81900000.	.000	.061	.025	.003
303003020	81900000.	.001	.102	.025	.037
303003030	88000000.	NEGLIGIBLE	.009	.003	.017
303003040	88000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.013
303003050	81900000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.016
303003990	36700000.	NEGLIGIBLE	.011	.004	.002
303004000	1390000.	NEGLIGIBLE	.006	.001	.132
303004010	1390000.	NEGLIGIBLE	.006	.001	.132
303005000		NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.347
303005020	175000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.000
303005030	1654000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.021
303005040	1654000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.019
303005050	1654000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.004
303005060	300000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.300
303005990	1654000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.003
303006000	4333800.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.160

Table 7-2-a. 1976 PRIMARY METALS EMISSIONS AND CHARGE RATES (Continued)

INDUSTRIAL PROCESS, PRIMARY METALS PAGE 2

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
303006010	74500.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.003
303006020	381000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.023
303006030	310850.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.034
303006040	750000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.091
303006050	107400.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.004
303006990	2710000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.005
303007000	2480000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.003
303007010	960000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.000
303007020	1520000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.002
303008000		NEGLIGIBLE	NEGLIGIBLE	7.020	.486
303008010	80000000.	NEGLIGIBLE	NEGLIGIBLE	6.000	.048
303008020	80000000.	NEGLIGIBLE	NEGLIGIBLE	0.000	.017
303008030	51000000.	NEGLIGIBLE	NEGLIGIBLE	1.020	.096
303008040	111200000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.083
303008050	117000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.012
303008060	4400000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.006
303008990	117000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.226
303009000	147490000.	.010	.008	4.271	.093
303009010	8200000.	NEGLIGIBLE	NEGLIGIBLE	0.000	.022
303009020	10100000.	NEGLIGIBLE	NEGLIGIBLE	0.000	.013
303009030	64000000.	NEGLIGIBLE	NEGLIGIBLE	4.000	.016
303009040	20900000.	NEGLIGIBLE	NEGLIGIBLE	.188	.014
303009050	6586400.	NEGLIGIBLE	NEGLIGIBLE	.059	.004
303009990	37700000.	.010	.008	.024	.024
303010000	6742000.	.000	.000	NEGLIGIBLE	.012
303010010	771000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.006
303010020	771000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.005
303010990	5200000.	.000	.000	NEGLIGIBLE	.001
303011000		NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.013

Table 7-2-a. 1976 PRIMARY METALS EMISSIONS AND CHARGE RATES (Continued)

INDUSTRIAL PROCESS, PRIMARY METALS PAGE 3

ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC	TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
303011010	112000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.006
303011020	56500000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.003
303011990	168000000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.004
303012000	65000.	NEGLIGIBLE	NEGLIGIBLE	.002	NEGLIGIBLE
303012010	65000.	NEGLIGIBLE	NEGLIGIBLE	.002	NEGLIGIBLE
303030000	1554000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.005
303030010	614000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.003
303030040	940000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	.002
303999000	31200000.	.001	.001	.002	.047
303999990	31200000.	.001	.001	.002	.047

Table 7-2-b. 1976 PRIMARY METALS UNCERTAINTIES

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                       INDUSTRIAL PROCESS, PRIMARY METALS                   PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976      RUN DATE= MAR 22,1977
MODIFIED         TACRP               EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC        (SCC UNITS)        NOX            HC             CD          PART

303000010  +     4224700.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .006
           -     4224700.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .006

303001000  +     8828500.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .214
           -     3899300.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .044

303001010  +      177490.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .025
           -      177490.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .026
303001020  +     8000000.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .212
           -     1124000.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .030
303001030  +       73082.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .009
           -       73082.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .013
303001040  +      335410.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .005
           -      335410.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .006
303001050  +      148000.     + 0.000        + 0.000        + 0.000      +  .000
           -      148000.     - 0.000        - 0.000        - 0.000      -  .000
303001990  +     3710800.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .015
           -     3710800.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .015

303002000  +      715940.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .037
           -      715940.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .045

303002010  +      715940.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .037
           -      715940.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .045

303003000  +    24758000.     +  .000        +  .018        +  .005      +  .035
           -    24758000.     -  .001        -  .051        -  .027      -  .039

303003010  +     9130200.     +  .000        +  .009        +  .004      +  .002
           -     9130200.     -  .000        -  .026        -  .025      -  .001
303003020  +     9130200.     +  .000        +  .015        +  .004      +  .031
           -     9130200.     -  .001        -  .044        -  .010      -  .035
303003030  +    11893000.    NEGLIGIBLE      +  .001        +  .000      +  .011
           -    11893000.    NEGLIGIBLE      -  .004        -  .001      -  .011
303003040  +    11893000.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .011
           -    11893000.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .012
303003050  +     9130200.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .002
           -     9130200.    NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .002
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Table 7-[illegible]-b. 1976 PRIMARY METALS UNCERTAINTIES (Continued)

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                     INDUSTRIAL PROCESS, PRIMARY METALS                     PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976        RUN DATE= MAR 22,1977
 MODIFIED           TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)          NOX             HC              CO           PART
303003990   +     8944300.       NEGLIGIBLE    +  .003      +  .001       +  .001
            -     8944300.       NEGLIGIBLE    -  .003      -  .001       -  .001

303004000   +      132570.       NEGLIGIBLE    +  .001      +  .000       +  .029
            -      132570.       NEGLIGIBLE    -  .001      -  .000       -  .021

303004010   +      132570.       NEGLIGIBLE    +  .001      +  .000       +  .029
            -      132570.       NEGLIGIBLE    -  .001      -  .000       -  .021

303005000                        NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .051
                                 NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .054

303005020   +      406470.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .001
            -      175000.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .000
303005030   +      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .014
            -      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .021
303005040   +      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .015
            -      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .019
303005050   +      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .002
            -      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .003
303005060   +    34986000.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .046
            -    34986000.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .046
303005990   +      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .003
            -      128060.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .003

303006000   +      933990.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .142
            -      933990.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .075

303006010   +       13536.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .002
            -       13536.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .002
303006020   +       70182.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .015
            -       70182.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .01
303006030   +        8451.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .019
            -        8451.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .024
303006040   +      275860.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .059
            -      275860.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .069
303006050   +       85440.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    +  .004
            -       85440.       NEGLIGIBLE    NEGLIGIBLE   NEGLIGIBLE    -  .004
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Table 7-2-b. 1976 PRIMARY METALS UNCERTAINTIES (Continued)

INDUSTRIAL PROCESS, PRIMARY METALS PAGE 3

TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976 RUN DATE= MAR 22,1977

MODIFIED SCC		TACRP (SCC UNITS)	EMISSIONS (MILLIONS OF TONS / YEAR) NOX	HC	CO	PART
303006990	+	885300.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .127
	-	885300.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .005
303007000	+	569650.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .002
	-	569650.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .002
303007010	+	178890.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .000
	-	178890.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .000
303007020	+	540830.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .002
	-	540830.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .002
303008000			NEGLIGIBLE	NEGLIGIBLE	+ 1.047	+ .297
			NEGLIGIBLE	NEGLIGIBLE	- 1.047	- .264
303008010	+	8352200.	NEGLIGIBLE	NEGLIGIBLE	+ 1.016	+ .025
	-	8352200.	NEGLIGIBLE	NEGLIGIBLE	- 1.016	- .048
303008020	+	8352200.	NEGLIGIBLE	NEGLIGIBLE	+ 0.000	+ .009
	-	8352200.	NEGLIGIBLE	NEGLIGIBLE	- 0.000	- .017
303008030	+	11180000.	NEGLIGIBLE	NEGLIGIBLE	+ .251	+ .094
	-	11180000.	NEGLIGIBLE	NEGLIGIBLE	- .251	- .096
303008040	+	46390000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .094
	-	46390000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .083
303008050	+	20304000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .025
	-	20304000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .012
303008060	+	656050.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .001
	-	656050.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .001
303008990	+	20304000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	+ .263
	-	20304000.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	- .226
303009000	+	12158000.	+ .002	+ .002	+ .760	+ .039
	-	12158000.	- .010	- .008	- .760	- .042
303009010	+	4069700.	NEGLIGIBLE	NEGLIGIBLE	+ 0.000	+ .023
	-	4069700.	NEGLIGIBLE	NEGLIGIBLE	- 0.000	- .022
303009020	+	4903100.	NEGLIGIBLE	NEGLIGIBLE	+ 0.000	+ .013
	-	4903100.	NEGLIGIBLE	NEGLIGIBLE	- 0.000	- .013
303009030	+	6676100.	NEGLIGIBLE	NEGLIGIBLE	+ .759	+ .009
	-	6676100.	NEGLIGIBLE	NEGLIGIBLE	- .759	- .016

Table 7-2-b. 1976 PRIMARY METALS UNCERTAINTIES (Continued)

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                          INDUSTRIAL PROCESS, PRIMARY METALS                    PAGE  4
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976        RUN DATE= MAR 22,1977
 MODIFIED          TACRP                   EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX            HC             CO           PART

303009040   +      3981200.      NEGLIGIBLE     NEGLIGIBLE     +  .041       +  .013
            -      3981200.      NEGLIGIBLE     NEGLIGIBLE     -  .046       -  .014
303009050   +       665920.      NEGLIGIBLE     NEGLIGIBLE     +  .009       +  .003
            -       665920.      NEGLIGIBLE     NEGLIGIBLE     -  .011       -  .004
303009990   +      6809000.      +  .002        +  .002        +  .005       +  .024
            -      6809000.      -  .010        -  .008        -  .024       -  .024

303010000   +      1010100.      +  .000        +  .000        NEGLIGIBLE    +  .006
            -      1010100.      -  .000        -  .000        NEGLIGIBLE    -  .008

303010010   +       10)300.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .004
            -       106300.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .006
303010020   +       106300.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .004
            -       106300.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .005
303010990   +       99889(.      +  .000        +  .000        NEGLIGIBLE    +  .000
            -       998890.      -  .000        -  .000        NEGLIGIBLE    -  .000

303011000                        NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .003
                                 NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .003

303011010   +     15620000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .001
            -     15620000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .002
303011020   +      7810200.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .002
            -      7810200.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .002
303011990   +     23431000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .001
            -     23431000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .001

303012000   +         9999.      NEGLIGIBLE     NEGLIGIBLE     +  .001       NEGLIGIBLE
            -         9999.      NEGLIGIBLE     NEGLIGIBLE     -  .001       NEGLIGIBLE

303012010   +         9999.      NEGLIGIBLE     NEGLIGIBLE     +  .001       NEGLIGIBLE
            -         9999.      NEGLIGIBLE     NEGLIGIBLE     -  .001       NEGLIGIBLE

303030000   +       191010.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .001
            -       191010.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .001

303030010   +        93722.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    +  .001
            -        93722.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE    -  .001
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Table 7-2-b. 1976 PRIMARY METALS UNCERTAINTIES (Continued)

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                        INDUSTRIAL PROCESS, PRIMARY METALS                     PAGE  5
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1976.          RUN DATE= MAR 22,1977
 MODIFIED            TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC           (SCC UNITS)        NOX             HC              CO            PART
303030040   +       166430.     NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE     +  .001
            -       166430.     NEGLIGIBLE      NEGLIGIBLE      NEGLIGIBLE     -  .001
303999000   +      4386300.     +  .000         +  .000         +  .000        +  .008
            -      4386300.     -  .001         -  .000         -  .001        -  .008
303999990   +      4386300.     +  .000         +  .000         +  .000        +  .008
            -      4386300.     -  .001         -  .000         -  .001        -  .008
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Table 7-3-a. 1981 PRIMARY METALS EMISSIONS AND CHARGE RATES

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                          INDUSTRIAL PROCESS, PRIMARY METALS                      PAGE  1
         ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
 MODIFIED        TACRP                 EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC        (SCC UNITS)       NOX            HC             CO            PART

303000010     20560000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .001

303001000     23362000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .039

303001010      2576000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .015
303001020      1164000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .014
303001030      1026000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .006
303001040      3600000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .000
303001050      1496000.        0.000          0.000          0.000          .000
303001990     13500000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .005

303002000      9374000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .009

303002010      9374000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .009

303003000    458400000.         .002           .184           .056          .032

303003010     81900000.         .000           .061           .025          .000
303003020     81900000.         .001           .102           .025          .006
303003030     88000000.     NEGLIGIBLE         .009           .003          .008
303003040     88000000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .001
303003050     81900000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .016
303003990     36700000.     NEGLIGIBLE         .011           .004          .001

303004000      1390000.     NEGLIGIBLE         .006           .001          .056

303004010      1390000.     NEGLIGIBLE         .006           .001          .056

303005000                   NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .312

303005020            0.        0.000          0.000          0.000         0.000
303005030      1654000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .009
303005040      1654000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .002
303005050      1654000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .001
303005060    300000000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .300
303005990      1654000.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .000

303006000      4127200.     NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE        .030
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Table 7-3-a. 1981 PRIMARY METALS EMISSIONS AND CHARGE RATES (Continued)

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                          INDUSTRIAL PROCESS, PRIMARY METALS                  PAGE  2
ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED         TACRP                  EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC         (SCC UNITS)           NOX          HC            CO            PART

303006010          98200.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001
303006020         451000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .006
303006030         317700.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .007
303006040         510000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .015
303006050          90500.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .000
303006990        2710000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001

303007000        2680000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001

303007010        1160000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .000
303007020        1520000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001

303008000                        NEGLIGIBLE   NEGLIGIBLE        4.510         .144

303008010       80000000.        NEGLIGIBLE   NEGLIGIBLE        4.000         .048
303008020       80000000.        NEGLIGIBLE   NEGLIGIBLE        0.000         .017
303008030       51000000.        NEGLIGIBLE   NEGLIGIBLE         .510         .043
303008040       83200000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .008
303008050      117000000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .002
303008060        6400000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .002
303008990      117000000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .023

303009000      135420000.           .010         .008           2.087         .021

303009010              0.          0.000        0.000           0.000        0.000
303009020              0.          0.000        0.000           0.000        0.000
303009030       64000000.        NEGLIGIBLE   NEGLIGIBLE        1.760         .016
303009040       26900000.        NEGLIGIBLE   NEGLIGIBLE         .242         .003
303009050        6819500.        NEGLIGIBLE   NEGLIGIBLE         .061         .001
303009990       37700000.           .010         .008            .024         .001

303010000        6932000.           .000         .000      NEGLIGIBLE         .004

303010010         866000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001
303010020         866000.        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .003
303010990        5200000.           .000         .000      NEGLIGIBLE         .000

303011000                        NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .007
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Table 7-3-a. 1981 PRIMARY METALS EMISSIONS AND CHARGE RATES (Continued)

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                       INDUSTRIAL PROCESS, PRIMARY METALS                  PAGE  3
 ANNUAL CHARGE RATES AND EMISSIONS PROJECTED TO 1981     RUN DATE= MAR 22,1977
  MODIFIED        TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
    SCC        (SCC UNITS)          NOX          HC             CO          PART

 303011010      122000000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .003
 303011020       61500000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001
 303011990      183000000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .002

 303012000          65000.     NEGLIGIBLE   NEGLIGIBLE         .000   NEGLIGIBLE

 303012010          65000.     NEGLIGIBLE   NEGLIGIBLE         .000   NEGLIGIBLE

 303030000        1554000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .002

 303030010         614000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001
 303030040         940000.     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE         .001

 303999000       35200000.           .002         .001         .002         .053

 303999990       35200000.           .002         .001         .002         .053
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Table 7-3-b. 1981 PRIMARY METALS UNCERTAINTIES

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                    INDUSTRIAL PROCESS, PRIMARY METALS                    PAGE  1
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981         RUN DATE= MAR 22,1977
MODIFIED          TACRP           EMISSIONS (MILLIONS OF TONS / YEAR)
  SCC          (SCC UNITS)         NOX            HC             CO           PART

303000010   +     4277700.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .001
            -     4277700.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .001

303001000   +     8970700.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .096
            -     4222000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .022

303001010   +      217710.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .014
            -      217710.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .015
303001020   +     8000300.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .095
            -     1164000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .014
303001030   +       89643.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .002
            -       89643.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .006
303001040   +      424260.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .000
            -      424260.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .000
303001050   +      186130.      + 0.000        + 0.000        + 0.000        +  .000
            -      186130.      - 0.000        - 0.000        - 0.000        -  .000
303001990   +     4024900.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .004
            -     4024900.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .005

303002000   +      779610.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .008
            -      779610.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .009

303002010   +      779610.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .008
            -      779610.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .009

303003000   +    68177000.      +  .000        +  .042        +  .012        +  .011
            -    68177000.      -  .001        -  .116        -  .034        -  .011

303003010   +    27586000.      +  .000        +  .022        +  .009        +  .000
            -    27586000.      -  .000        -  .059        -  .025        -  .000
303003020   +    27586000.      +  .000        +  .036        +  .009        +  .006
            -    27586000.      -  .001        -  .099        -  .024        -  .006
303003030   +    31822000.      NEGLIGIBLE     +  .003        +  .001        +  .007
            -    31822000.      NEGLIGIBLE     -  .009        -  .003        -  .008
303003040   +    31822000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .000
            -    31822000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .001
303003050   +    27586000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     +  .006
            -    27586000.      NEGLIGIBLE     NEGLIGIBLE     NEGLIGIBLE     -  .006
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Table 7-3-b. 1981 PRIMARY METALS UNCERTAINTIES (Continued)

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                          INDUSTRIAL PROCESS, PRIMARY METALS                        PAGE  2
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981          RUN DATE= MAR 22,1977
 MODIFIED           TACRP                EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)          NOX            HC              CO            PART

303003990    +    18439000.       NEGLIGIBLE     +  .000         +  .002        +  .001
             -    18439000.       NEGLIGIBLE     -  .000         -  .003        -  .001

303004000    +      158690.       NEGLIGIBLE     +  .001         +  .000        +  .056
             -      158690.       NEGLIGIBLE     -  .003         -  .000        -  .056

303004010    +      158690.       NEGLIGIBLE     +  .001         +  .000        +  .056
             -      158690.       NEGLIGIBLE     -  .003         -  .000        -  .056

303005000                         NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .076
                                  NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .076

303005020    +           0.       + 0.000        + 0.000         + 0.000        + 0.000
             -           0.       - 0.000        - 0.000         - 0.000        - 0.009
303005030    +      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .007
             -      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .009
303005040    +      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .000
             -      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .002
303005050    +      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .001
             -      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .001
303005060    +    69778000.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .076
             -    69778000.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .076
303005990    +      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .000
             -      359030.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .000

303006000    +     1595700.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .026
             -     1586000.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .018

303006010    +       27018.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .001
             -       27018.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .001
303006020    +      140090.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .005
             -      140090.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .006
303006030    +       14566.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .006
             -       14566.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .007
303006040    +      488470.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .020
             -      488470.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .015
303006050    +      182480.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     +  .001
             -       50'00.       NEGLIGIBLE     NEGLIGIBLE      NEGLIGIBLE     -  .000
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Table 7-3-b. 1981 PRIMARY METALS UNCERTAINTIES (Continued)

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                      INDUSTRIAL PROCESS, PRIMARY METALS                  PAGE  3
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981        RUN DATE= MAR 22,1977
                                       EMISSIONS (MILLIONS OF TONS / YEAR)
 MODIFIED         TACRP
   SCC         (SCC UNITS)     NOX             HC            CO              PART
303006990  +     1501300.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .013
           -     1501300.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .001

303007000  +      952170.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .001
           -      952170.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .001

303007010  +      368780.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .000
           -      368780.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .000
303007020  +      877850.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .001
           -      877850.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .001

303008000                   NEGLIGIBLE    NEGLIGIBLE     + 2.395         +  .058
                            NEGLIGIBLE    NEGLIGIBLE     - 1.870         -  .071

303008010  +    16473000.   NEGLIGIBLE    NEGLIGIBLE     + 2.306         +  .026
           -    16473000.   NEGLIGIBLE    NEGLIGIBLE     - 1.800         -  .048
303008020  +    16473000.   NEGLIGIBLE    NEGLIGIBLE     + 0.000         +  .009
           -    16473000.   NEGLIGIBLE    NEGLIGIBLE     - 0.000         -  .017
303008030  +    20616000.   NEGLIGIBLE    NEGLIGIBLE     +  .648         +  .041
           -    20616000.   NEGLIGIBLE    NEGLIGIBLE     -  .510         -  .043
303008040  +    58412000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .010
           -    58412000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .008
303008050  +    29000000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .005
           -    29000000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .002
303008060  +     1236500.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .002
           -     1236500.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .002
303008990  +    29000000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       +  .027
           -    29000000.   NEGLIGIBLE    NEGLIGIBLE    NEGLIGIBLE       -  .023

303009000  +    20216000.    +  .003       +  .003       + 2.750         +  .010
           -    20216000.    -  .010       -  .008       - 1.769         -  .017

303009010  +          0.     + 0.000       + 0.000       + 0.000         + 0.000
           -          0.     - 0.000       - 0.000       - 0.000         - 0.000
303009020  +          0.     + 0.000       + 0.000       + 0.000         + 0.000
           -          0.     - 0.000       - 0.000       - 0.000         - 0.000
303009030  +    13074000.   NEGLIGIBLE    NEGLIGIBLE     + 2.749         +  .009
           -    13074000.   NEGLIGIBLE    NEGLIGIBLE     - 1.760         -  .016
```

Table 7-3-b. 1981 PRIMARY METALS UNCERTAINTIES (Continued)

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                      INDUSTRIAL PROCESS, PRIMARY METALS                    PAGE  4
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981      RUN DATE= MAR 22,1977
 MODIFIED          TACRP              EMISSIONS (MILLIONS OF TONS / YEAR)
   SCC          (SCC UNITS)        NOX          HC           CO           PART

303009040   +      9749400.   NEGLIGIBLE   NEGLIGIBLE    +  .092      +  .002
            -      9749400.   NEGLIGIBLE   NEGLIGIBLE    -  .172      -  .003
303009050   +       762230.   NEGLIGIBLE   NEGLIGIBLE    +  .010      +  .000
            -       762230.   NEGLIGIBLE   NEGLIGIBLE    -  .038      -  .001
303009990   +     11922000.    +  .003      +  .003      +  .008      +  .000
            -     11922000.    -  .010      -  .008      -  .024      -  .001

303010000   +      1629200.    +  .000      +  .000     NEGLIGIBLE    +  .003
            -      1629200.    -  .000      -  .000     NEGLIGIBLE    -  .003

303010010   +       193130.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .000
            -       193130.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .001
303010020   +       193130.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .003
            -       193130.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .003
303010990   +      1606100.    +  .000      +  .000     NEGLIGIBLE    +  .000
            -      1606100.    -  .000      -  .000     NEGLIGIBLE    -  .000

303011000                     NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .004
                              NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .004

303011010   +     24166000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .003
            -     24166000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .003
303011020   +     12083000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .001
            -     12083000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .001
303011990   +     36249000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .002
            -     36249000.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .002

303012000   +        18973.   NEGLIGIBLE   NEGLIGIBLE    +  .003     NEGLIGIBLE
            -        18973.   NEGLIGIBLE   NEGLIGIBLE    -  .000     NEGLIGIBLE

303012010   +        18973.   NEGLIGIBLE   NEGLIGIBLE    +  .003     NEGLIGIBLE
            -        18973.   NEGLIGIBLE   NEGLIGIBLE    -  .000     NEGLIGIBLE

303030000   +       341090.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .001
            -       341090.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .001

303030010   +       172750.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    +  .000
            -       172750.   NEGLIGIBLE   NEGLIGIBLE   NEGLIGIBLE    -  .001
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Table 7-3-b. 1981 PRIMARY METALS UNCERTAINTIES (Continued)

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                          INDUSTRIAL PROCESS, PRIMARY METALS                    PAGE  5
TACR AND EMISSION UNCERTAINTIES PROJECTED TO 1981        RUN DATE= MAR 22,1977
                                            EMISSIONS (MILLIONS OF TONS / YEAR)
MODIFIED            TACRP                 NOX            HC            CO          PART
  SCC            (SCC UNITS)
                                      NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE     + .001
303030040    +      294110.           NEGLIGIBLE     NEGLIGIBLE    NEGLIGIBLE     - .001
             -      294110.
                                                      + .000        + .000        + .013
303999000    +     7800000.        +  .000           - .001        - .002        - .013
             -     7800000.        -  .002
                                                      + .000        + .000        + .013
303999990    +     7800000.        +  .000           - .001        - .002        - .013
             -     7800000.        -  .002
```

Although nearly 90 percent of the CO forme does get collected and burned, approximately 150 lb of CO per ton of pig iron escape to the atmosphere. Much of these losses occur during charging exercises, but some are lost through leaks and inadvertent bypass procedures. Most of the CO and PART lost to the atmosphere occurs during "slips." A slip is caused when a bridge of stock forms in the furnace just above the molten slag. The bridge eventually collapses after the material beneath moves downward far enough to remove its support. Accompanying the collapse of the bridge is a rush of blast furnace gas to the top of the furnace, creating a momentary high pressure condition. The dust and CO-laden gas escapes through relief valves and bleeder ports to the atmosphere. Closer control of charge material has helped to reduce the occurrence of slips. Also, the increased operating pressure of the furnace and dust collection system has reduced the frequency at which the relief valves are opened to dump the emissions into the atmosphere. Few improvements are expected in the collection of blast furnace gas without substantial costs. These costs may become acceptable if the CO could be used as a chemical reactant to produce a useful product such as methanol rather than to burn it as the low grade fuel.

According to Ref. 7-2, the blast furnace gas contains 7 to 30 grains of dust per standard cubic foot (scf). Before the gas can be effectively used as a fuel, the PART must be removed. The first stage of dust removal involves either a cyclone or settling chamber, which removes about 60 percent of the pollutant. The second stage is normally a wet scrubber, which removes about 90 percent of the remaining dust. The final stage typically is an electrostatic precipitator, which can remove 90 percent of the remaining solid emissions. The system yields a 99.6 percent overall efficiency of particle collection.

For the purpose of this inventory, the general sintering operation is considered to be a part of pig iron production. The sinter operation supplies the blast furnaces with pellets consisting of a mixture of concentrated iron ore and fine coal. This operation is also a major source of CO and PART emissions. Control techniques are much the same as for the blast furnace, i.e., a dust collection system consisting of cyclone separators and electrostatic precipitators.

7.3.2 Basic Oxygen Furnaces

The basic oxygen furnace (BOF) is used in producing steel from the molten pig iron from blast furnaces (70 percent) and from scrap metal (30 percent). Unlike the blast furnace, no fuel such as coke is added to the charge in the BOF. Instead, the carbon, silicon, and other impurities are oxidized by injecting a stream of oxygen toward the molten metal charge. The oxidized silicon, manganese, and phosphorus slip into the slag, but the oxidized carbon evolves as CO. Attempts at collection for future burning in waste heat boilers are hampered by PART removal and especially by the tendency to create an explosive atmosphere in the furnace exhaust system.

The furnace gas contains CO, which is generated at the rate of 120 to 160 lb/ton of steel produced. Usually, an excess of air is simply mixed with the CO and the mixture burned as a flare, instead of being cleaned and burned in waste heat boilers. This eliminates the possibility of an explosion within the exhaust system. The CO concentration after combustion is reduced to about 3 lb/ton of steel produced. The bulk of the CO emissions to the atmosphere results from leakages and failure to collect all of the furnace gas.

As much as 40 to 50 lb of PART are generated per ton of steel produced by the BOF. Reference 7-3 lists standards of performance which when implemented would limit the particulate emissions to undiluted 0.022 grains/scf from newly installed BOFs. The limits can be achieved with high energy venturi scrubbers.

7.3.3 Primary Copper Smelting and Refining

The yield is low for copper ore (about 0.005 percent according to Table 2 of Ref. 7-4). As a result, dust and PART are emitted simply because of the large quantity of ore that must be handled to produce the copper refined in the U.S. Four major processes in the smelting of copper are the primary sources of PART emissions.

The first process, roasting, is performed only on ores with high sulfur content. Other ores can be fed directly to the reverberator furnace. Recent improvements in furnace design may eliminate the need for roasting. The use of the older multiple hearth roasters has been phased out of some plants, according to Ref. 7-5. The roasters operate at a temperature near 12°F, and consequently dust collection is easily managed without elaborate cooling equipment.

The second process takes place in the reverberatory furnace which melts the metal-bearing charge and forms the copper entrained matte stream. Approximately 50 percent of the PART is less than 37 μm; consequently, collection and recovery of dust from the furnace gas is difficult.

The third process occurs in the copper converter which accepts the molten matte from the reverberatory furnace. The function of the converter is to oxidize and remove iron and sulfur from the matte stream. About 80 percent of the particulate matte in the gas stream from the converter is large enough to settle out in the flue system. The remainder is processed through scrubbers, collectors, and electrostatic precipitators. Based on the per unit amount of concentrated ore entering the roaster or furnace, the emission factor of PART from the converter is the highest of any process in copper smelting.

Refining is the final process in copper production. This process enables copper products to meet the high purity specifications for many copper products.

7.4 EMISSIONS ANALYSIS

This section describes certain hypotheses, assumptions, and observations that were made in the process of establishing the data base on which the charge rate and emission rate calculations were made.

7.4.1 Blast Furnace and Related Operations

Although there is good agreement among technical sources regarding the quantities of CO generated in the blast furnaces used to produce pig iron, Ref. 7-6 lists a value of 1750 lb of CO per ton of iron for an emission factor. Since this is a value near the typical number reported as the total CO generated per ton of iron, this can be used as a representative emission factor only if no controls are in effect, i.e., if all of the CO generated is permitted to escape to the atmosphere.

In this analysis, an effective CO emission factor was derived from the NEDS data by dividing the CO emissions (in pounds) by the charge rate (in tons) from Ref. 7-1. Although CO is likely to escape to the atmosphere from the blast furnace during any of many operations including ore and agglomerate charging and especially during the "slips" described in Section 7.3.1, all of the CO emissions from blast furnaces in this study are grouped under MSCC 303008010, entitled Blast Furnace Ore Charging.

So that the emissions might be based on the latest data, the base line charge rates were extracted from Ref. 7-7.

7.4.2 Basic Oxygen Furnace

CO is generated in the basic oxygen furnace (BOF) at a rate of about 150 lb/ton of steel produced. Although this can be reduced to near zero (3 or 5 lb/ton) by flaring or another combustion process, energy conservation tends to motivate the use of CO in waste heat boilers. The collection and cleaning of PART, necessary before using the CO as a fuel, impose a potentially explosive atmosphere.

Both of these two techniques for combustion of the CO waste have undesirable features. No safe means of collecting and cleaning the gas has been demonstrated. It was assumed, therefore, that the effective emission factor in 1975 was the one that corresponded to uncontrolled conditions (139 lb/ton of steel). The effective emission factor, however, is expected to decrease linearly to near zero by 1985.

The 1976 CO emissions from the BOF are ± 0.75 million tons. In 1981, these will be reduced to 1.75 plus 2.75 or minus 1.75 million tons. The inordinately large uncertainty is due primarily to the unknown element of time in developing a safe collection system.

7.4.3 Copper Smelters

Good data exist on production rates of refined copper. However, most emission factor data are based on raw or, more often, on concentrated ore (Ref. 7-6). The ratio of concentrated ore to refined copper is approximately 4.0, according to page 139 of Ref. 7-5. This is the ratio that was used in calculating the emissions from copper smelters and related operations. Production rates were extracted from Refs. 7-4, 7-5, and 7-7 to establish baseline charge rates and slopes.

The quantities of PART emissions generated in each operation are highly sensitive to such factors as the chemical composition of the copper matte, the temperature of the converter, the fineness of the charge, and the degree of agitation in charging. As a result, a high degree of uncertainty exists for the uncontrolled emission factor. Fifteen percent uncertainty was used in these analyses.

7.5 REFERENCES

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7-5. Particulate Pollutant System Study, U.S. Environmental Protection Agency, Washington, D.C., prepared by Midwest Research Institute.

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APPENDIX A

CONVERSION FACTORS

To Convert From	To	Multiply By
Barrel (42 gallons)	Cubic meters	1.590×10^{-1}
British thermal unit	Joules	1.055×10^{3}
Fahrenheit (temperature)	Kelvin	$T_K = \frac{5}{9}(T_F + 459.67)$
Foot	Meters	3.048×10^{-1}[a]
Gallon (U.S. liquid)	Cubic meters	3.785×10^{-3}
Horsepower $\left(550 \frac{\text{ft-lbs}}{\text{sec}}\right)$	Watts	7.457×10^{2}
Inch	Meters	2.54×10^{-2}[a]
Lb_f (pound force)	Newtons	4.448
Lb_m (pound mass)	Kilograms	4.536×10^{-1}
Ton (short, 2000 pounds)	Kilograms	9.072×10^{-2}
Lb_m per gallon	Kilogram per cubic meters	1.198×10^{2}
Cubic feet	Cubic meters	2.832×10^{-2}
Lb_m per cubic foot	Kilograms per cubic meter	1.602×10^{1}
Btu per ton	Joules per kilogram	1.163
Btu per gallon	Joules per cubic meter	2.787×10^{5}
Btu per cubic foot	Joules per cubic meter	3.726×10^{4}

[a] Exact.

APPENDIX B

GLOSSARY

ACR	annual charge rate
API	American Petroleum Institute
bhp	brake horsepower
BTX	Benzene, toluene, xylene
CO	carbon monoxide
EEI	Edison Electric Institute
EPA	Environmental Protection Agency
H_2	hydrogen
HC	hydrocarbons
IC	internal combustion
KPPH	thousands of pounds per hour
MMBtu/hr	millions of British thermal units per hour
MSCC	modified source classification code
N	nitrogen
NEC	not elsewhere classified
NEDS	National Emissions Data System
nm	nanometer (formerly millimicron)
NH_3	ammonia
NO_x	oxides of nitrogen

PART	particulate matter
PPM	parts per million
SCC	source classification code (NEDS)
SIC	standard industrial classification
SO_2	sulfur dioxide
TACRP	total annual charge rate projected
T_F	temperature, degree Fahrenheit
T_k	temperature, Kelvin